# BRITAIN'S
# FIGHTING FORCES

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By CAPTAIN ELLISON HAWKS, R.A.

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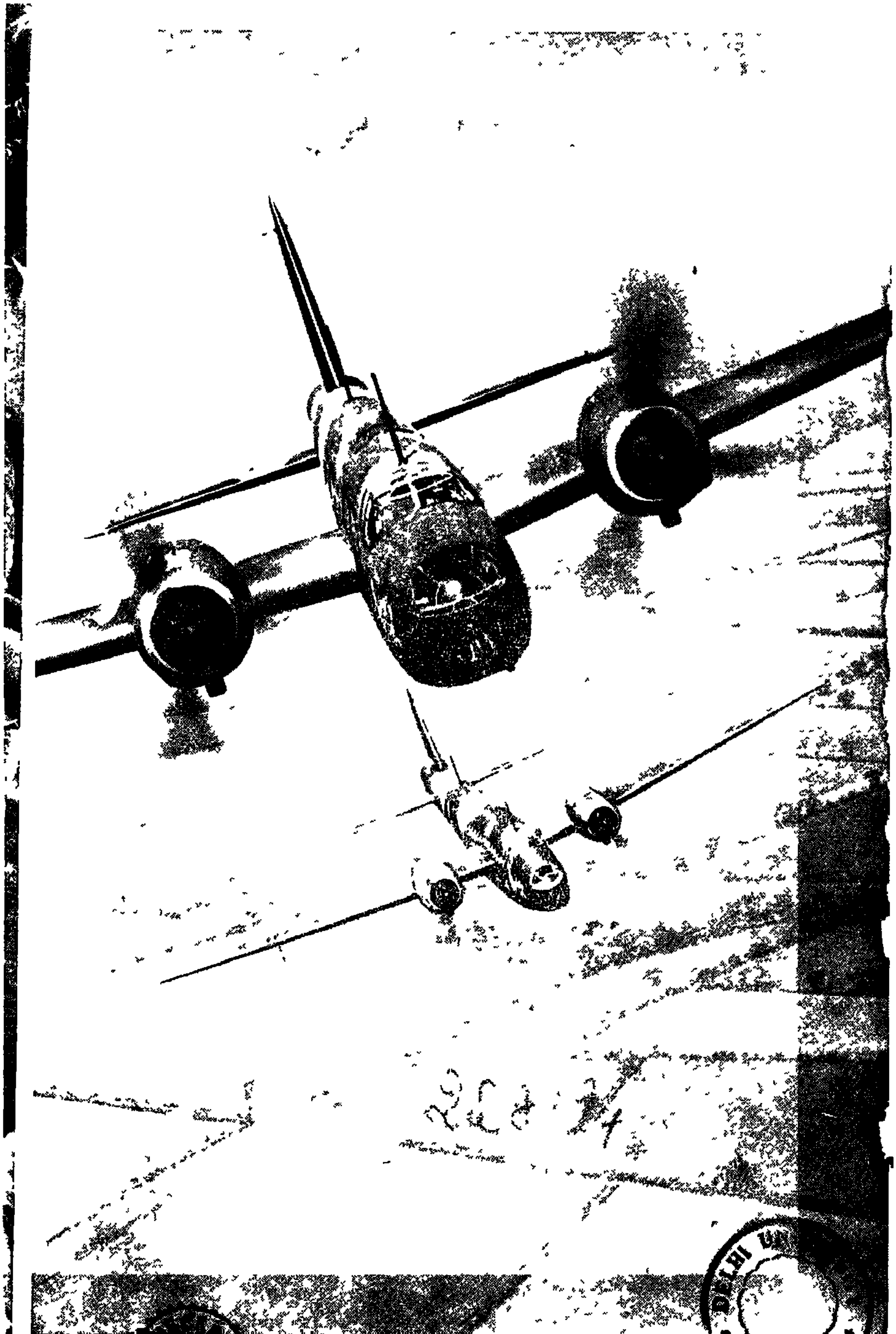

BRITAIN'S WINGED WARRIORS

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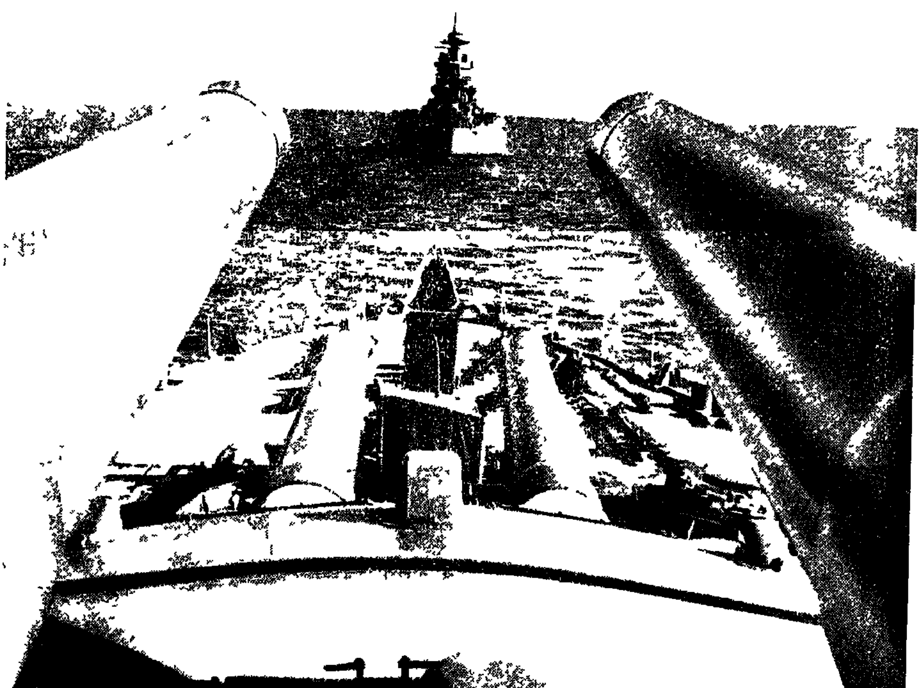


"OUR UNCHALLENGEABLE NAVY"

# FOREWORD

### BY THE FIRST SEA LORD, ADMIRAL OF THE FLEET

## SIR DUDLEY POUND, G C B, G C V O.

It is with great pleasure that I write a foreword to this volume, "Britain's Wonderful Fighting Forces," a book which will help all those who are giving their services to their country to gain knowledge of the work of the three Fighting Services in the great ordeal which lies before us

The task of the Navy is to exercise command of the sea in the areas where it is necessary for our ships to navigate with freedom and safety whilst denying such areas to the enemy In practice we have to exercise this command not only in home waters but in all the oceans, so that we can maintain the trade which is vital to our existence, cut off the enemy's supplies from overseas, and transport our land and air forces to such localities as the grand strategy of the war may demand

In the old wars the task of the Navy, if not easy, was comparatively simple, as our enemies had only surface ships with which to dispute control of the ocean The march of science, however, has resulted in the appearance of aircraft, the submarine and the mine, and has rendered the problem one of great complexity. In one way, and one way only, has science made things easier orders can now be flashed instantaneously by wireless telegraphy all over the world, and if Nelson were alive today I feel sure that this is the development which would appeal to him most

The protection of our trade from air attack, submarine attack and the mine, necessitates not only the co-operation of the Air Force, which is so readily given, but also the employment of an auxiliary fleet composed of a vast number of small craft, which on the outbreak of war must be taken from their peace time duties and adapted to war—a matter of considerable time

Until this auxiliary fleet materializes the Navy has to put in an amount of sea time which is only possible owing to the good construction of our ships and the endurance and skill of the personnel

To man these additional vessels we have to supplement the active service personnel of the Fleet by Naval Pensioners, men of the Royal Naval Reserve, the Royal Naval Volunteer Reserve, the Royal Naval Volunteer (Wireless) Reserve and the Royal Naval Volunteer Supplementary Reserve, all of whom are doing admirable work in the Fleet today

All would, however, be in vain without the courage and determination of those gallant officers and men of the Merchant Navy, who carry on in spite of all that the enemy so unsuccessfully does to drive them from the seas

To deal with the three Services in one volume was a happy inspiration on the part of the author, as it is yet another sign of the close co-operation and happy relations which exist at the present time between the Navy, the Army and the Air Force

Dudley Pound.

MEN OF STEEL

# INTRODUCTION

At eleven o'clock on Sunday morning, September 3, 1939, Britain declared war on Germany for the second time within a quarter of a century. There was not a man or woman in the whole of Britain who did not hate the foul necessity. None the less, neither the mother country nor the Empire hesitated for a moment. The arrogant challenge of despotism had been flung in the face of democracy. Everything that was worth-while in civilization was imperilled by that challenge and would have been forfeited—possibly for ever—were it not taken up. With leaden hearts, but with resolute minds, the people of the British Empire turned to the fearful task of combating their giant adversary.

Despite her love for peace, Britain in 1939 was not unready for war, as she had been in 1914 The ominous shadow of Nazi aggression had loomed horribly across the world in March, 1938, when Austria had been absorbed into Hitler's new Reich It had grown insidiously with the Sudeten crisis in September, 1938, and, despite the Munich settlement, there were few who believed that its growth had ceased The rape of Prague in March, 1939, opened the eyes of the most peace-loving to the appalling danger in which the civilized world stood

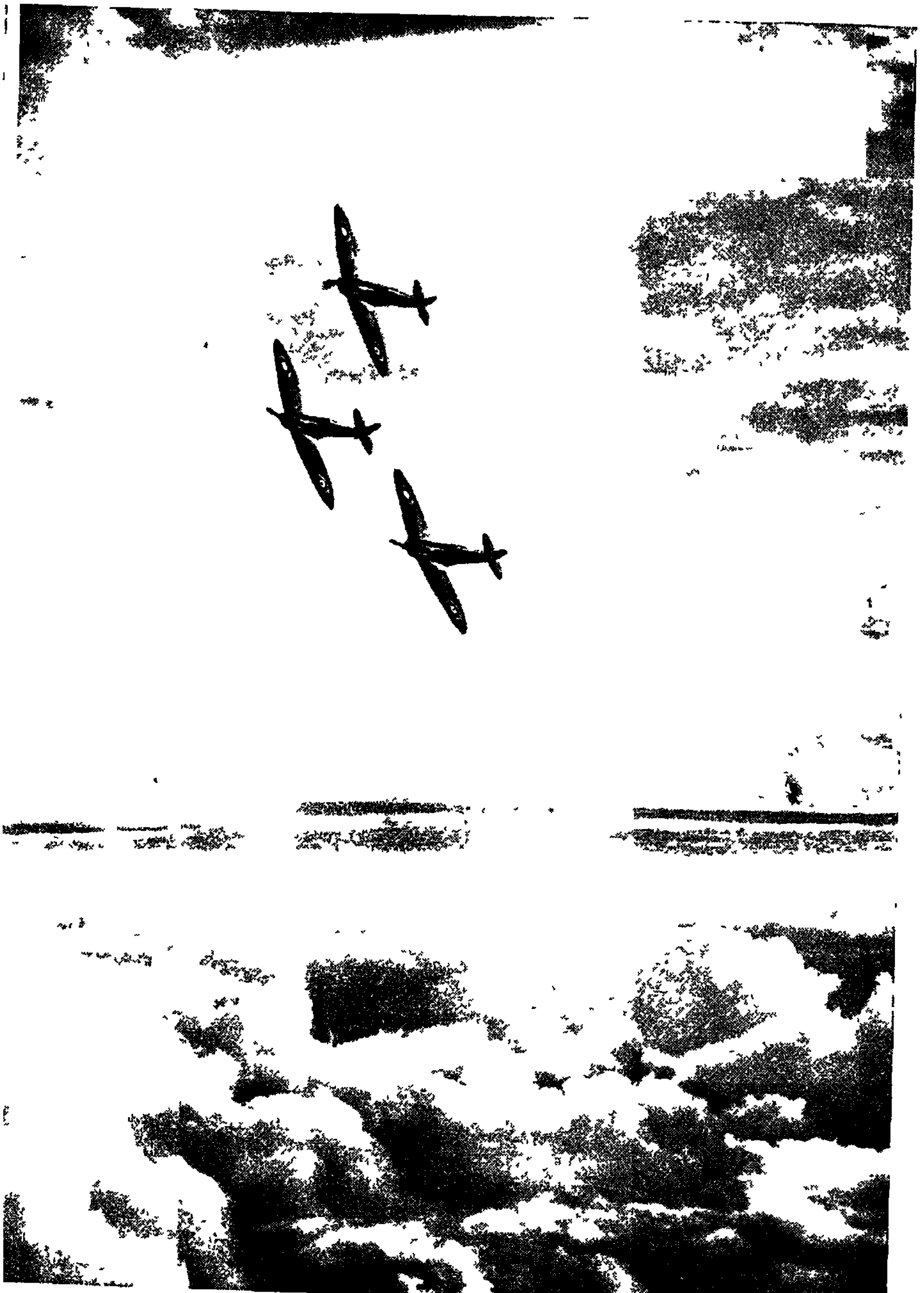
Britain was forewarned with reluctance she had begun to forearm The might of her industrial power was turned in those critical months, more and more from the satisfaction of the needs of peace to the preparation of the needs of war Her people even abandoned their sturdy insistence upon the freedom of the individual and accepted conscription.

How well had been begun the task of equipping Britain for the greatest struggle in all her history may be seen in the pages which follow. In one respect, Britain was supreme; her Navy still held the command of the seas. New and revolutionary inventions in the mechanics of war have affected the Navy as they have affected the Army and the Air Force. And today Britain's Navy is a more powerful force than it has ever been in its history

The change which science has produced in the Army is, perhaps, even greater. It is scarcely an exaggeration to say that only in the spirit and courage which animates it is the British Army today the same as that of the past. For the rest it has been revolutionized This is an age of speed In Napoleon's day an army marched on its stomach. Today it rides behind the petrol engine.

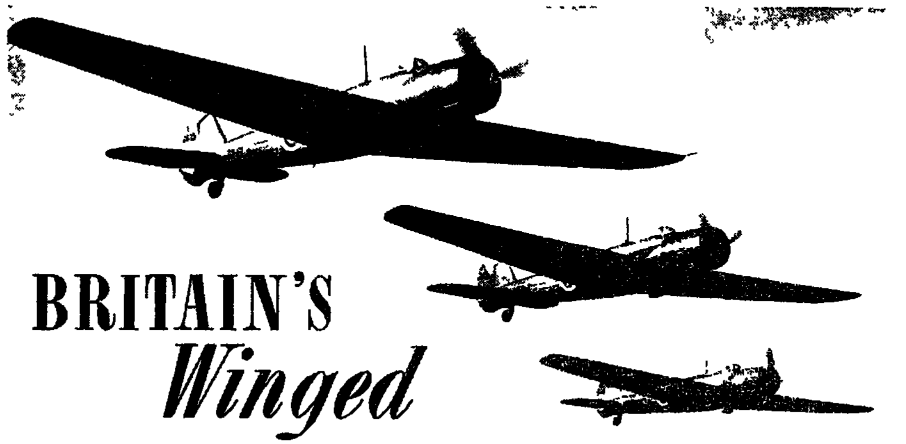
Similarly, the Royal Air Force, for all that it first spread its wings in the war of 1914-18, has undergone changes in the last twenty years quite as revolutionary The progress that has been made in the building of aeroplanes has placed new powers at the disposal of the air armadas of the world, powers so vast as to affect the whole strategy of air warfare

These changes that have been brought about in the military forces of the British crown have occurred at lightning speed The peace-loving citizens of Britain have suddenly found themselves the possessors of vast and complicated organizations of whose nature they know little, of whose workings they know less, and of many of whose weapons they know nothing at all This book is an attempt to remedy that lack of knowledge and to explain to those readers something of the complications and workings of Britain's fighting forces. If it succeeds in helping any one to understand a little more what those forces are doing and how they do it, it will have found its justification.



GUARDIANS OF BRITAIN'S SKIES

*On patrol—a flight of "Spitfires" flying in formation above the clouds.*



# BRITAIN'S *Winged* WARRIORS

## *SECTION I*

### CHAPTER I

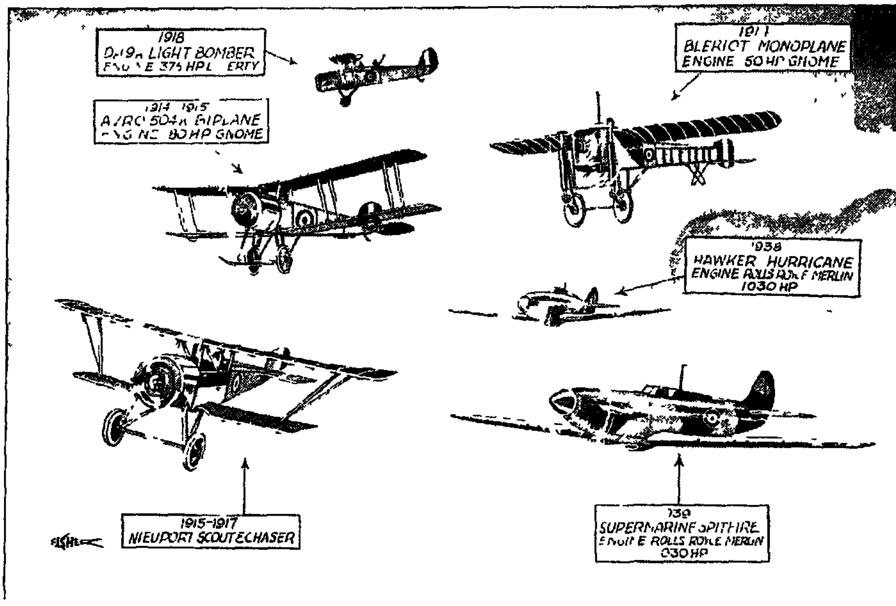
# AERIAL WARFARE

BEFORE the outbreak of war on September 3, 1939, it was popularly supposed, particularly in Britain, that the power of the aeroplane in modern warfare was all important. With considerable relief the peoples of Britain, France and Germany found in the first months of war that they were not called upon to endure the horrors of aerial bombardment as they had been schooled to expect. Indeed, there appeared to be a tacit understanding between the belligerent powers not seriously to conduct aerial or land warfare. Ferocity of struggle was reserved for that traditional battleground, the sea.

Even if the belief in the overwhelming power of the air weapon is exaggerated, it is clear that this weapon is of tremendous importance in modern warfare. Abyssinia, Spain, China and Poland are a sufficient lesson. But what distinguished those particular cases was the immense disparity between the aerial resources of the contending parties.

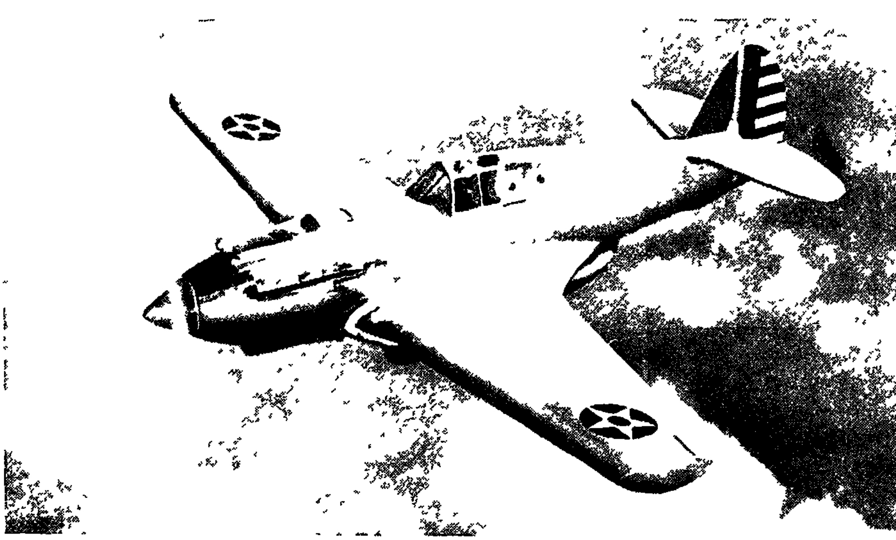
It is quite clear, however, that the power of a well organized and strong air defence has been for many years underestimated. For a time it was thought that the bomber was supreme. Earl Baldwin, when Premier of Great Britain, crystallized this belief in a phrase that has become memorable. "The bomber," he said, "will always get through." Technical developments in fighter aircraft design and production, and in the powers of ground defence, have raised doubts as to whether this remark is today as true as it was when made.

Today, the bomber is no longer supreme and the cost to an attacker in machines and personnel becomes increasingly high. Aerial fleets are, after all, very like naval fleets. Machines grow




DEVELOPMENT OF BRITISH MILITARY AIRCRAFT

**Fig. 1.** *The development of British military aircraft has made enormous strides since 1914 Apart from a revolution in constructional methods, the chief difference is that there has been an immense specialization, every machine today being designed for a specific purpose*



CURTISS "P-40" PURSUIT PLANE

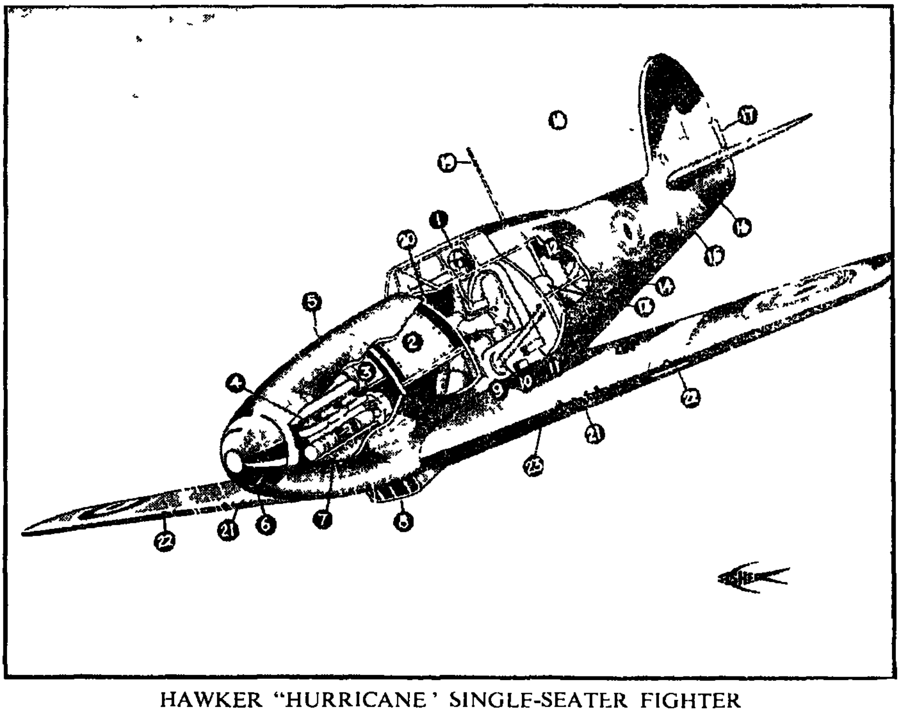
*This American machine, one of the fastest fighter aircraft in the world, has a reputed top speed of 400 m p h The Allied Purchasing Board in the U S A secured the American Army's permission for the export of this and similar machines to Britain and France*

increasingly expensive to build and difficult to replace and the personnel requires more and more specialized training Resources must accordingly be husbanded and against well-equipped opponents an attacking power may well suffer such aerial losses, if he launches a large scale and determined offensive, as would cripple him for the remainder of a war.

Such considerations as these were far more influential than political considerations in determining the air strategy of Germany at the commencement of the war.

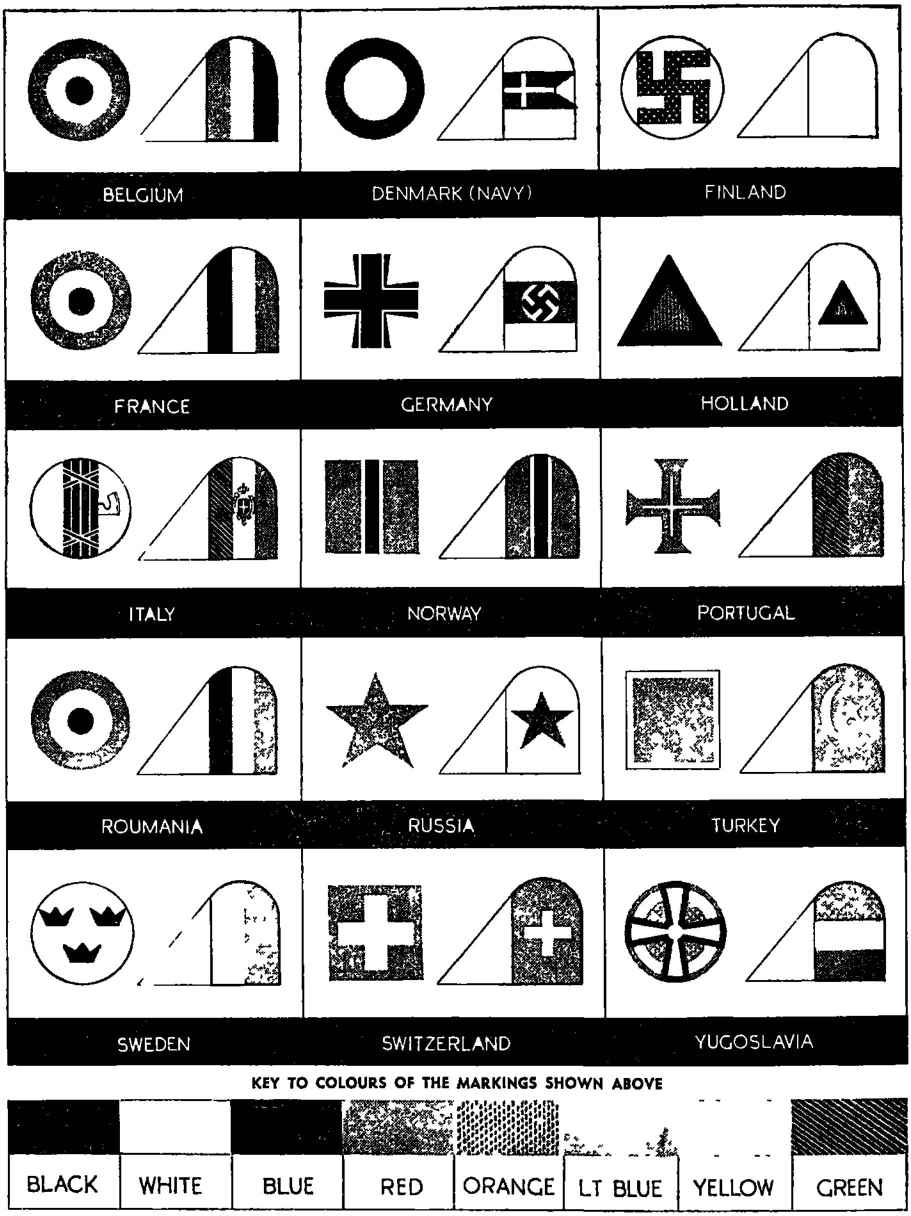
Against Poland, whose air force was appallingly ill-equipped, she had little to fear and she utilized the advantages that her overwhelming air power gave her with a high degree of skill. Indeed, Germany's use of an air arm in the Polish campaign may become a model for future military historians and strategists.

But Germany's position *vis-à-vis* Britain and France was very different. Here were two powers possessing a combined air force that, although possibly slightly inferior in numbers, was superior in machines and personnel It Hitler had not been restrained by his General Staff, it is probable that he would have launched his bombers in mass flights over London,



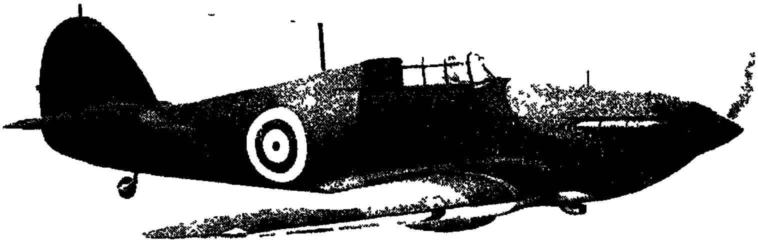
HAWKER "HURRICANE" SINGLE-SEATER FIGHTER

**Fig. 2** *This fighter has a speed of over 335 m p h, and with the "Spitfire" is Britain's leading interceptor fighter 1, Pilot 2, Fuel tank 3, Header tank 4, Exhausts 5, Front bead sights 6, Spinners 7, Rolls-Royce "Merlin II" 1,030-h p engine (liquid cooled). 8, Air intake. 9, Throttle controls 10, Tail trimming tab control 11, Fuse box 12, Radio 13, Oxygen cylinder 14, Parachute flares 15, Fabric covering 16, Tail wheel retracted 17, Rudder trimming tab 18, Aerial 19, Aerial mast 20, Instrument panel. 21, Four Browning machine guns 22, Landing light 23, Undercarriage retracted*




FUSELAGE AND TAIL MARKINGS OF WARPLANES OF VARIOUS NATIONS

*The fuselage marking, shown on the left in each instance, is placed on the wings and in the approximate centre of the aeroplane's body The tail marking, shown on the right, is found on each side of the rudder These insignia are essential to warplanes for purposes of identification In September, 1939, British warplanes carried wing and body markings, but did not display tail insignia The use of tail insignia was reintroduced early in 1940*



HAWKER "HURRICANE" FIGHTER AIRCRAFT

**Fig. 3.** *A Hawker "Hurricane" single-seater fighter in flight This picture affords an interesting comparison between the "Hurricane" and the "Spitfire" illustrated on page 17*

Paris and the other big cities of the Allies with ruthless determination to smash the morale of their peoples and thus to bring the war to a speedy conclusion Had he done so in those early days it is evident that he would have inflicted enormous damage, but he would never have broken the morale of the Allies, and it is certain he would have damaged his own air fleet very gravely He would, too, have invited reprisals under which the morale of his dragooned and miserable subjects might well have broken completely

### HOW AN AIR FORCE IS USED

These general conclusions must be borne in mind before a proper understanding of the significance of the aeroplane in modern warfare is possible. Air power as between two equally matched belligerents becomes a military weapon It may work independently, conducting a warfare of its own against the air force of the enemy. It may be used as a branch of the army working in close collaboration with the land forces Finally, it may work as an adjunct of the navy co-operating with naval vessels in every branch of their many and varied activities.

The more intense the struggle becomes, from the military and naval point of view, the more need will there be for the services of the aeroplane in these spheres Less time and resources will be available, in consequence, for attacks against civil populations In whatever capacity the air force may be used, however, the principles governing aerial warfare remain the same

For example, bombing attacks against civilian or military objectives are conducted by waves of planes and very seldom does any wave number more than twenty-five planes If aerial fleets were sent over in sufficient numbers (to quote the words of Mussolini) "to darken the sun," they would inevitably present a target that anti-aircraft guns could not miss Moreover, the fighters would be presented with a multiplicity of targets and, as the early months of warfare clearly established, fighters have a definite advantage over the bomber. Mass attacks would therefore suffer very heavy casualties. In consequence, bombing raids are carried out by a succession of waves of small numbers of planes. These waves follow each other at short intervals so that before

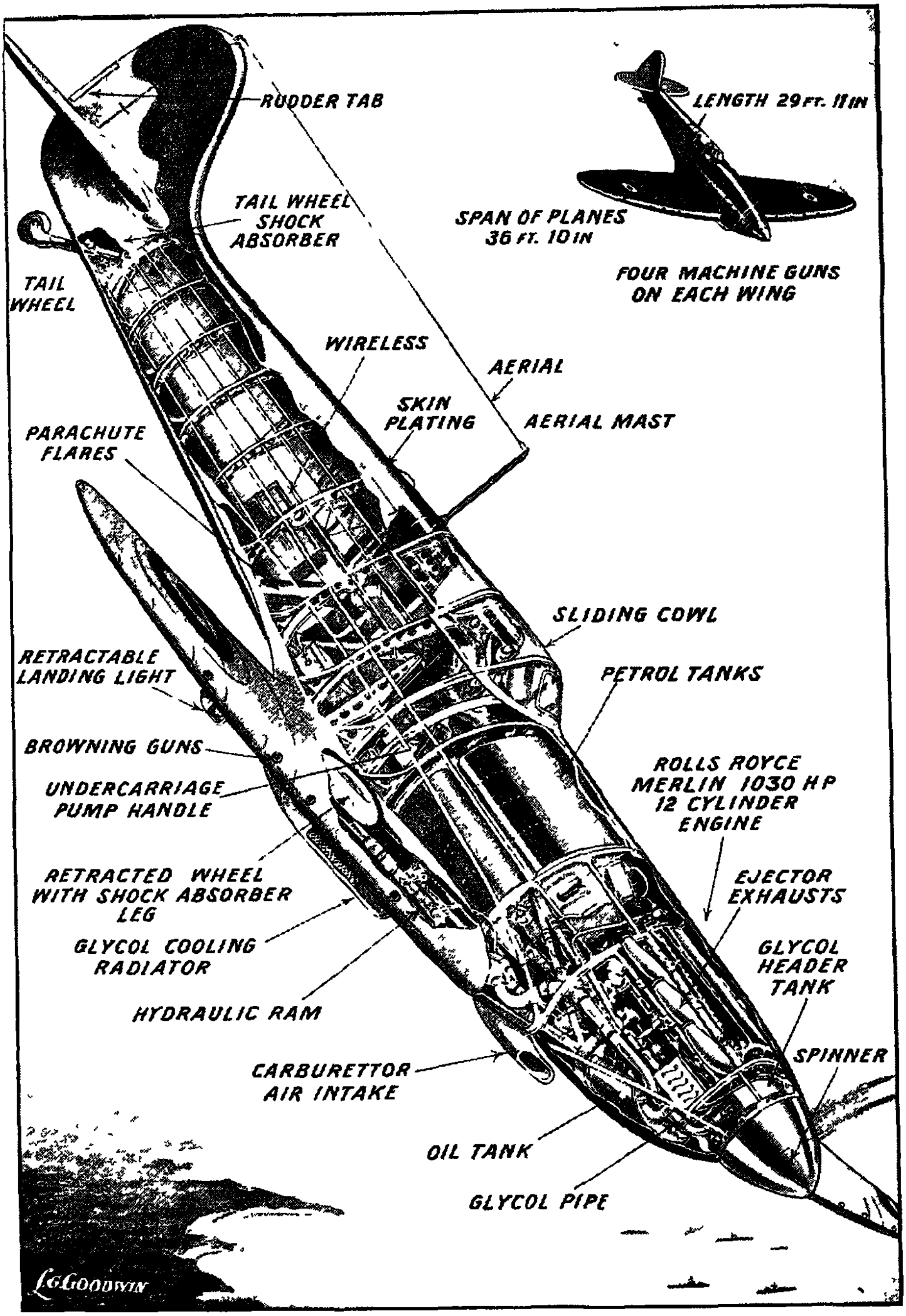


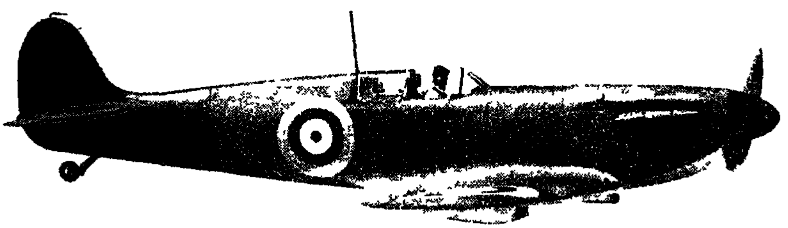

Fig. 4 *Vickers Supermarine "Spitfire," Britain's leading single-seater fighter*

the havoc and disorganization produced by one attack can be dealt with another is taking place Raids are also carried out on a number of different centres simultaneously In this way the defence is confused and defence equipment tends to be widely scattered.

This modern form of aerial attack has been made possible only by the enormous strides in technical development of the aeroplane since the war of 1914-18

An idea of the development of the military aeroplane during the last quarter of a century is given in Fig 1 The disparity in performance between these early military planes and those in use today is even more striking than the change in their appearance. It is interesting to note that the War Office laid down in 1912 that any aeroplane submitted for their approval must be capable of a minimum speed of fifty-five miles per hour in a calm, must be able to carry a useful load of 350 lb. together with fuel sufficient for four and a half hours' flying, must be capable of remaining in the air for at least three hours and of reaching an altitude of 4,500 feet. How different were the aeroplanes of Britain in September, 1939!

The chief point of difference, however, lies in the immense specialization that has overtaken aeroplane design. Every machine today is designed for a specific purpose. The chief division has been, of course, into the bomber and fighter categories. In fighter aircraft, Britain began the war with the finest aeroplanes in the world, the Hawker "Hurricane" (Figs 2 and 3) and the Supermarine "Spitfire" (Figs. 4 and 5) Both of these are fitted with 1,030-h.p Rolls-Royce "Merlin" engines. They are capable respectively of over 330 and 360 m p h.—speeds that would have appeared utterly fantastic and almost impossible to the pilots of 1918.



FAMOUS BRITISH FIGHTER IN FLIGHT

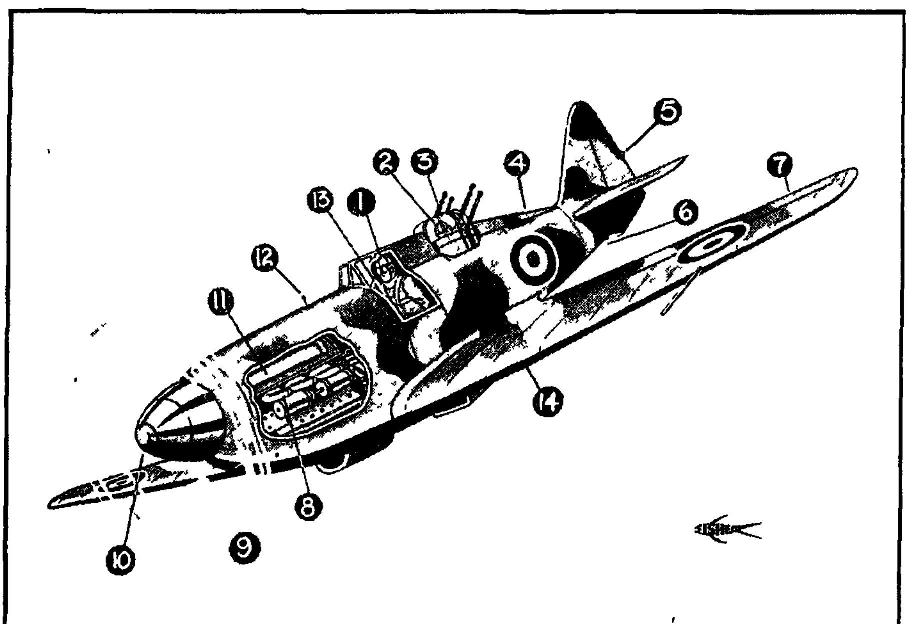
**Fig. 5.** *Side view of the "Spitfire" in flight showing its clean lines This machine proved most effective in numerous encounters with German bombing planes*

The "Spitfire," for example, can climb to 11,000 feet in well under five minutes and its maximum speed is 367 m p h How carefully these aircraft are designed, how well able they are to stand up to the enormous strains and stresses produced by high speeds were graphically illustrated by the experience of a young R.A.F pilot in January, 1940. He was flying a "Spitfire," an ordinary service machine, but, for some reason, was not using his oxygen supply. He lost consciousness at a height of 23,000 feet, and the aeroplane went into a steep dive. Just

in time he regained consciousness and pulled his machine out of the dive. He noticed that as it climbed vertically it was registering a speed of 400 m.p.h. To reach this speed in the climb, the "Spitfire" must have been travelling at well over 500 m p h. in the dive!

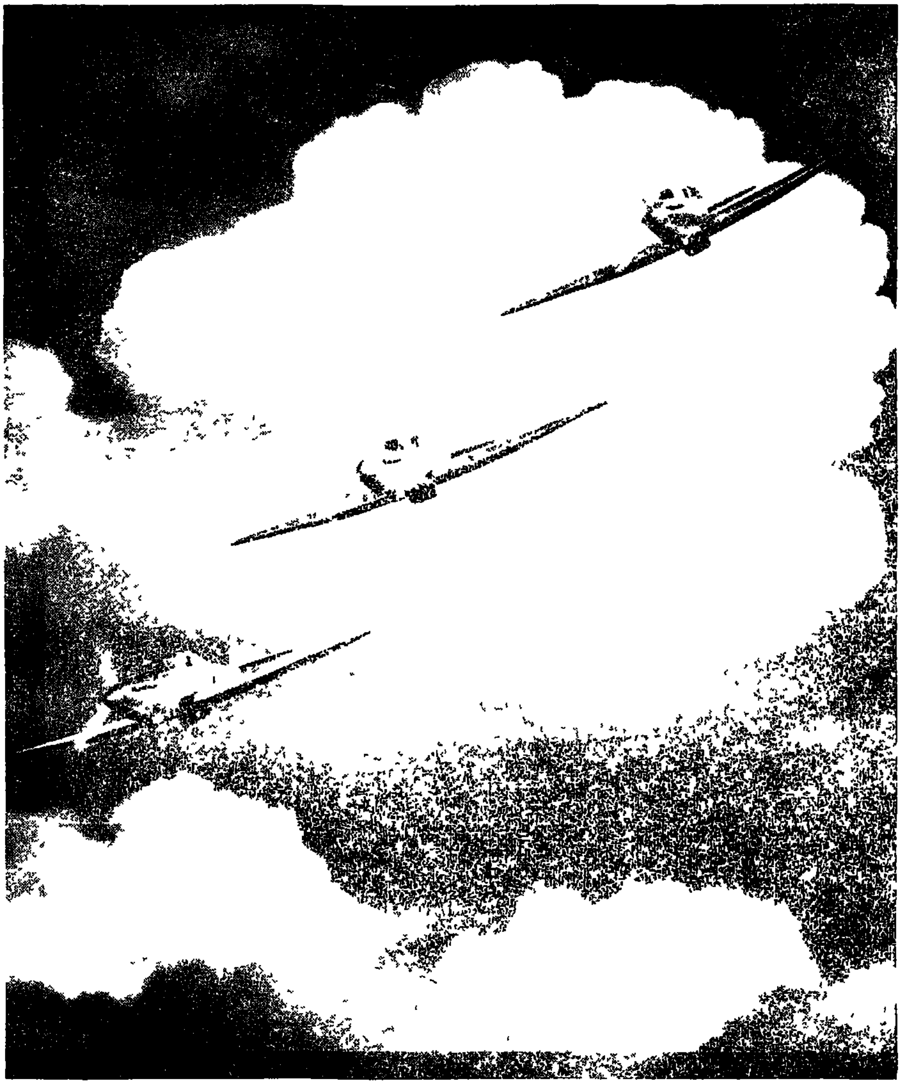
If the "Spitfire" has proved itself sound in aeronautical design, it has proved even more its merits as a fighter. Like the Hawker "Hurricane," it is armed with eight machine guns mounted in the wings and all firing forwards. Both aircraft are highly manœuvrable at speed and, before the end of 1939, the "Hurricane" had proved itself more than a match for its German counterpart, the Messerschmitt "109." The steady toll taken by both the "Spitfire" and the "Hurricane" of the German bombing planes that visited the shores of Great Britain has proved even more their astonishing powers in attack.

But even the "Spitfire" is not the last word in fighter aircraft production. By the beginning of 1940, Britain had in production a new venture in fighters, the Boulton Paul "Defiant" (Figs. 6 and 7). Fighter aircraft are essentially small machines that possess very high speeds and great manœuvrability. As such, they are incapable of long flights. Indeed, fighters like the Messerschmitt "109" and the "Spitfire" carry only enough petrol to keep them in the air for a short time—the exact period being determined by the throttle opening. The result is that whenever bomber aircraft set out on




BOULTON PAUL "DEFIANT" TWO-SEATER FIGHTER

**Fig. 6.** *This powerfully-armed fighter is fitted with a mechanically-operated gun turret. 1, Pilot. 2, Gunner observer. 3, Mechanically operated multi-gun turret. 4, Stressed-skin fuselage. 5, Tail light. 6, Retracted tail wheel. 7, Aileron. 8, Exhausts. 9, Variable-pitch three-blade airscrew. 10, Spinner. 11, 1,030-h.p. Rolls-Royce "Merlin" engine (liquid cooled). 12, Front bead sight. 13, Instrument panel. 14, Inward retracted undercarriage.*



THREE BOULTON PAUL "DEFIANTS" ON PATROL

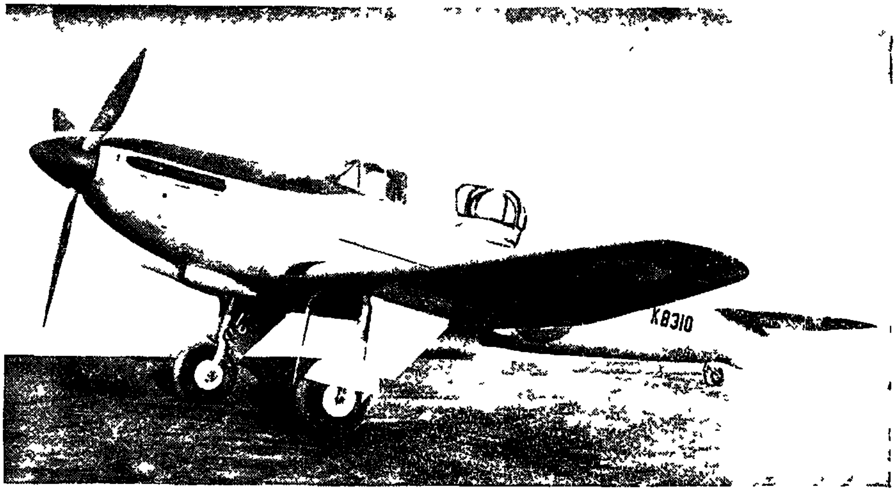
*This type of fighter has a remarkable range, and can be used to accompany bombers*

a raid they must go unaccompanied by fighters.

The "Defiant" is one of the machines that might meet this need for fighters that can accompany bombers. It is a two-seater low-wing monoplane of all-metal stressed-skin construction with an astonishing range and immense powers of attack and defence. It is powered by a single Rolls-Royce "Merlin" engine of 1,030 h.p., and has a wing span of 39 feet 6 inches. Its novel feature is a turret, mechanically operated, in which are installed two pairs of machine guns


SQUADRON BADGES AND MOTTOES OF THE R A F

*No 1 (Fighter) Squadron, "First in all things" No 26 (Army Co-operation) Squadron, "Sentinel of the skies" No 31 (Army Co-operation) Squadron, "First into the Indian skies" No 35 (Bomber) Squadron, "We act with one accord" No 39 (Bomber) Squadron, "By day and night" No 45 (Bomber) Squadron, "Through difficulties I arise" No 56 (Fighter) Squadron, "What if the heavens should fall?" No 64 (Fighter) Squadron, "Firm of purpose" No 269 (General Reconnaissance) Squadron, "We see everything"*



CLEAN LINES OF A MODERN TWO-SEATER FIGHTER

**Fig 7.** *Side view, close up, of the Boulton Paul 'Defiant,' a formidable two-seater fighter The four machine guns are not fitted to the mechanically operated turret in this illustration, but they may be seen in Fig 6 and in the illustration on page 5*

It also has forward-firing machine guns in the leading edges of the wings

Even the "Defiant" is not the last word in British military aircraft for by the end of February, 1940, there were in production a number of new and secret aircraft with performances that surpass all earlier models in every respect

### TYPES OF BRITISH AIRCRAFT

A number of the better-known British aircraft are seen in Figs 8A and 8B

Of the bombers, the Bristol "Blenheim" is perhaps the most celebrated There are three types of this aircraft The short-nosed "Blenheim I" (Fig. 9) is fitted with two 840-h.p Bristol "Mercury" engines These machines are of all-metal stressed-skin construction and have a total wing span of 56 feet 4 inches In addition to being used as reconnaissance bombers they also do duty as multi-seat fighters Their maximum speed has been recorded as 285 m p.h. at 15,000 feet and they are capable of cruising at 200 m p h for five and a half hours, and of climbing from ground level to 1,540 feet in one minute A modern successor to the "Blenheim" is the Bristol "Beaufort" (Fig 10) with an even higher performance than the earlier types Designed as a reconnaissance bomber, torpedo dropper, and general landplane, it has given a satisfactory performance in all its tests. It has a slightly larger wing span than the "Blenheim I," carries a crew of three, and is fitted with two 1,065-h p Bristol "Taurus" engines

The "Blenheims" belong to a type of aircraft intermediate between the interceptor fighters and the heavy bombers. They are capable of carrying a useful load of bombs over a long range, and yet are sufficiently manœuvrable and well-armed to be deadly fighters.

Another bomber, with long range, is the Vickers "Wellington" (Figs 11 and 12) and there is also the Armstrong-Whitworth "Whitley" (Fig. 13) The Vickers "Wellesleys" (Fig. 14) in 1938 gained the world non-stop flight record by flying 7,159 miles from Egypt to Australia at an

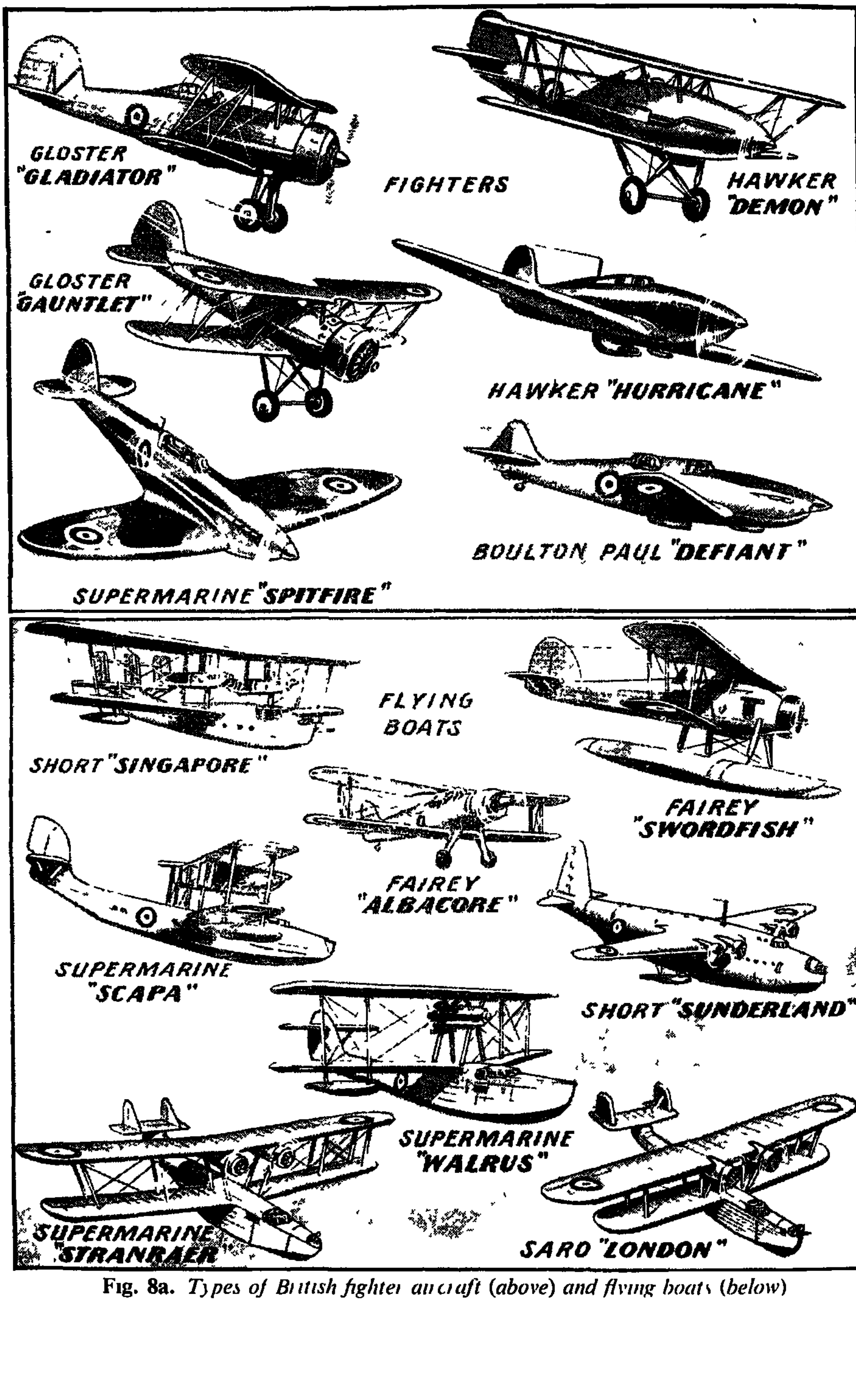



**Fig. 8a.** *Types of British fighter aircraft (above) and flying boats (below)*

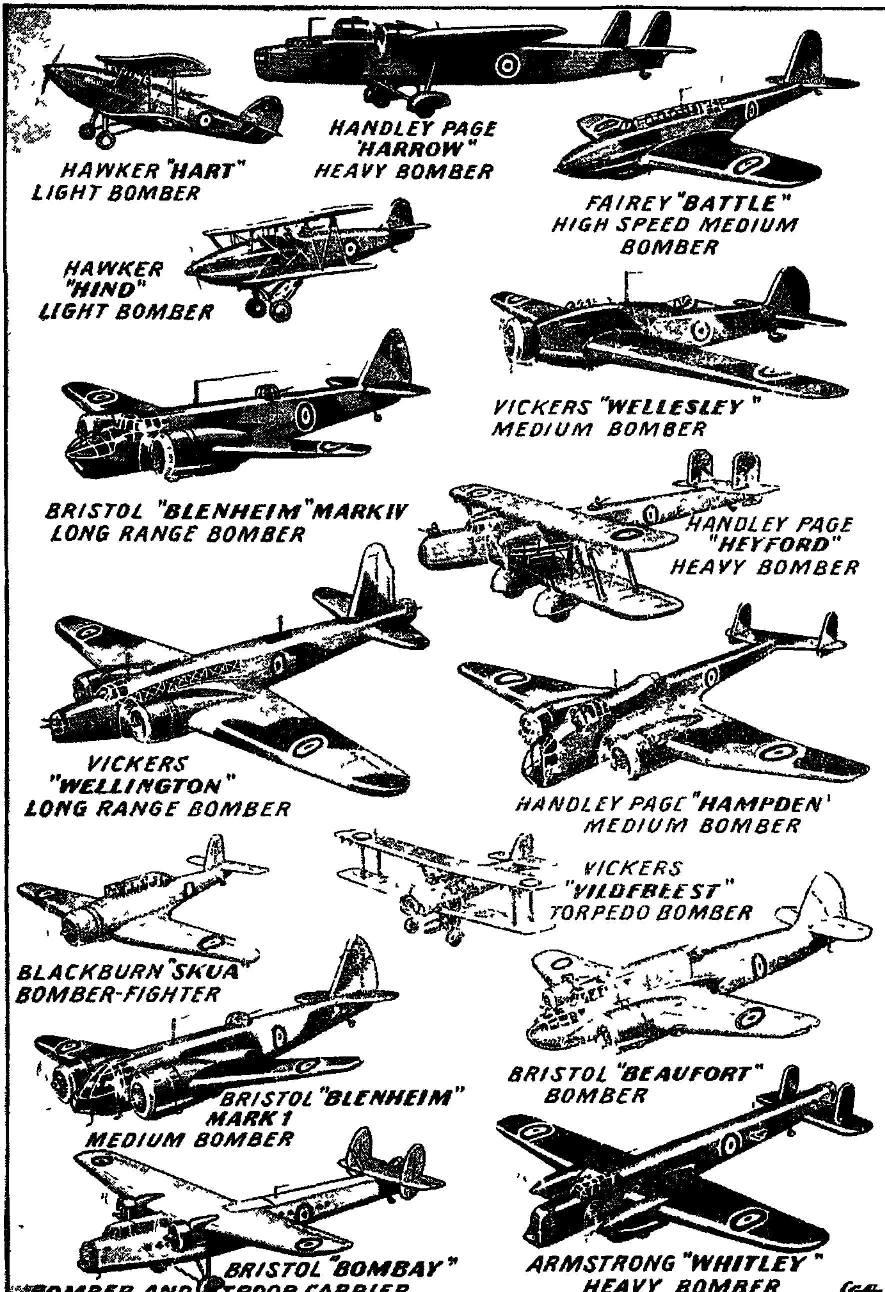
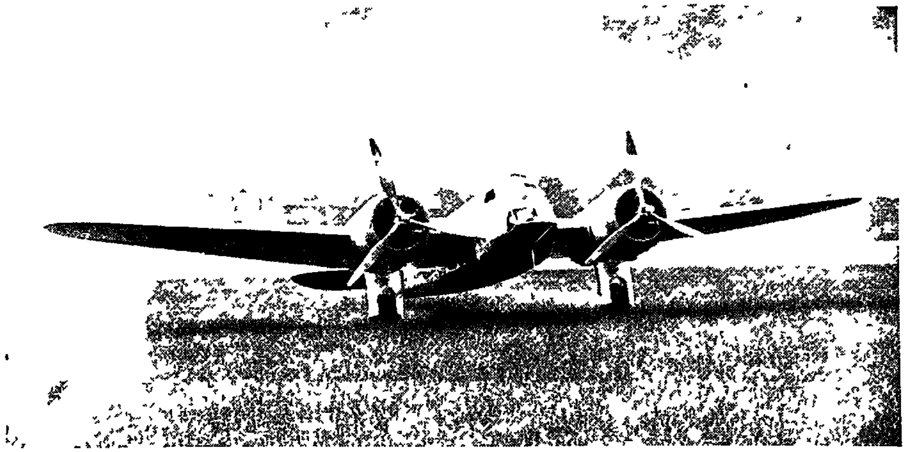



**Fig. 8b.** *Types of leading British bomber aircraft*

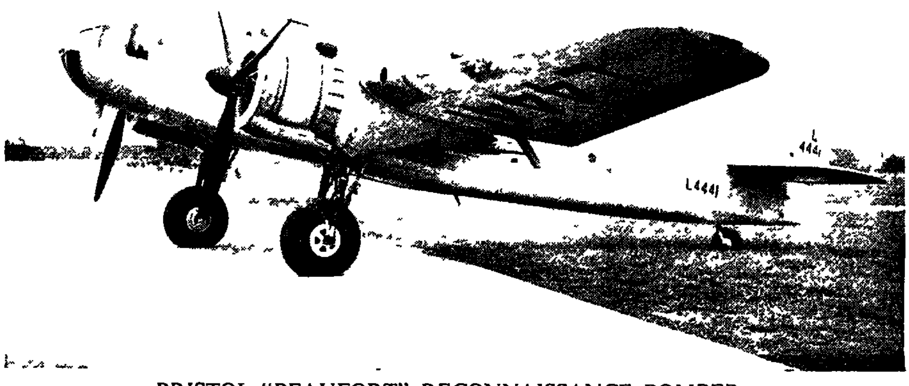


FORERUNNER OF THE MODERN "BLENHEIM" BOMBER

**Fig 9.** *The "Blenheim I," a short-nosed early type of the Bristol "Blenheim" bomber.*

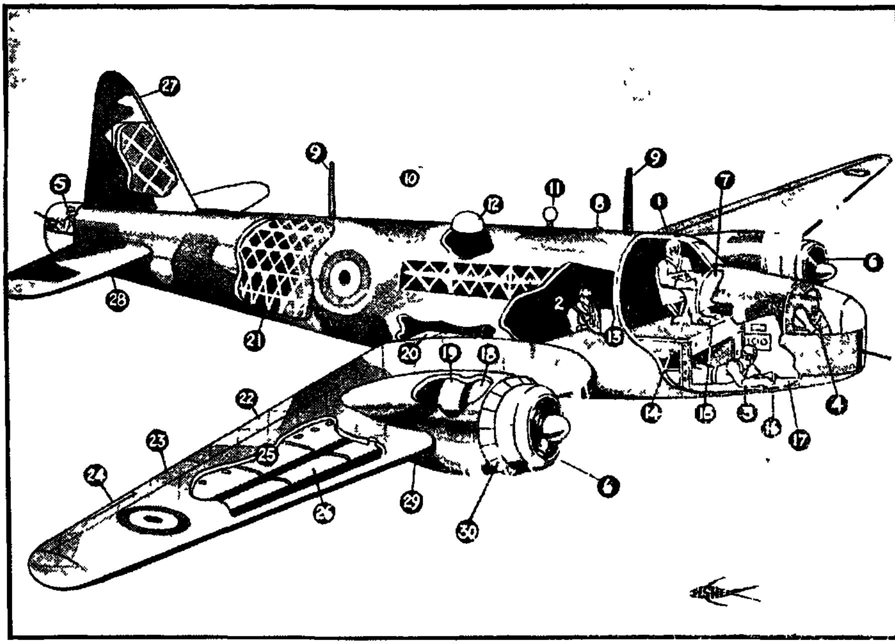
average speed of 149 m p.h The top speed of this remarkable machine is 228 m p.h at 19,680 feet, but it can cruise at 160 m p h for twelve hours Constructed on the geodetic principle combining strength with lightness, it is powered by a single 800-835-h.p. Bristol "Pegasus" engine Its wing span is 74 feet 7 inches and it has a movable gun between cockpit and rudder, as well as fixed machine guns firing forward.

The comparative ranges of the leading British bombers are shown in Fig 15. These early proved in a number of air actions—notably over German naval bases—that they were well able to justify the confidence felt in their ability to carry out raids on far-distant objectives.




BRISTOL "BEAUFORT" RECONNAISSANCE BOMBER

**Fig. 10.** *These machines, slightly larger than the "Blenheims," carry a crew of three*



VICKERS "WELLINGTON" MEDIUM BOMBER

**Fig. 11.** *This machine, a medium bomber of great range, is built on the geodetic principle 1, Pilot 2, Wireless operator 3, Bomb aimer's 4, Forward guns 5, Rear gunner's 6, 980-h p Bristol 'Pegasus' engine 7, Instrument panel 8, Navigator's sight 9, Aerial mast 10, Aerial 11, Directional loop 12, Observer's hatch 13, Radio 14, Control lever 15, Rudder bar 16, Course-setting bomb sight 17, Bomb aimer's window 18, Oil tank 19, Gravity fuel tank 20, Bomb doors 21, Geodetic structure 22, Flap 23 Aileron 24 Aileron trim tab 25, Aft fuel tanks 26, Front fuel tanks 27, Rudder mass-balance 28, Tail wheel retracted 29, Undercarriage retracted 30, Cooling gills*

Some interesting comparisons may be drawn between British aircraft and those of the French and German air forces First the French It is necessary to remember, when talking of the French Air Force that *L'Armée de l'Air* has been organized and produced mainly in the light of military requirements It was not until 1939 that our Allies began to produce long-range bombers in any numbers.

#### TYPES OF FRENCH AIRCRAFT

The chief types of French aircraft, illustrated in Fig 16, are as follows —

No. 1 is the twin-engined Potez "63 B2," a versatile light bomber, useful for reconnaissance work and speedily adaptable as a two-seater fighter Its maximum speed is approximately 290 m p h

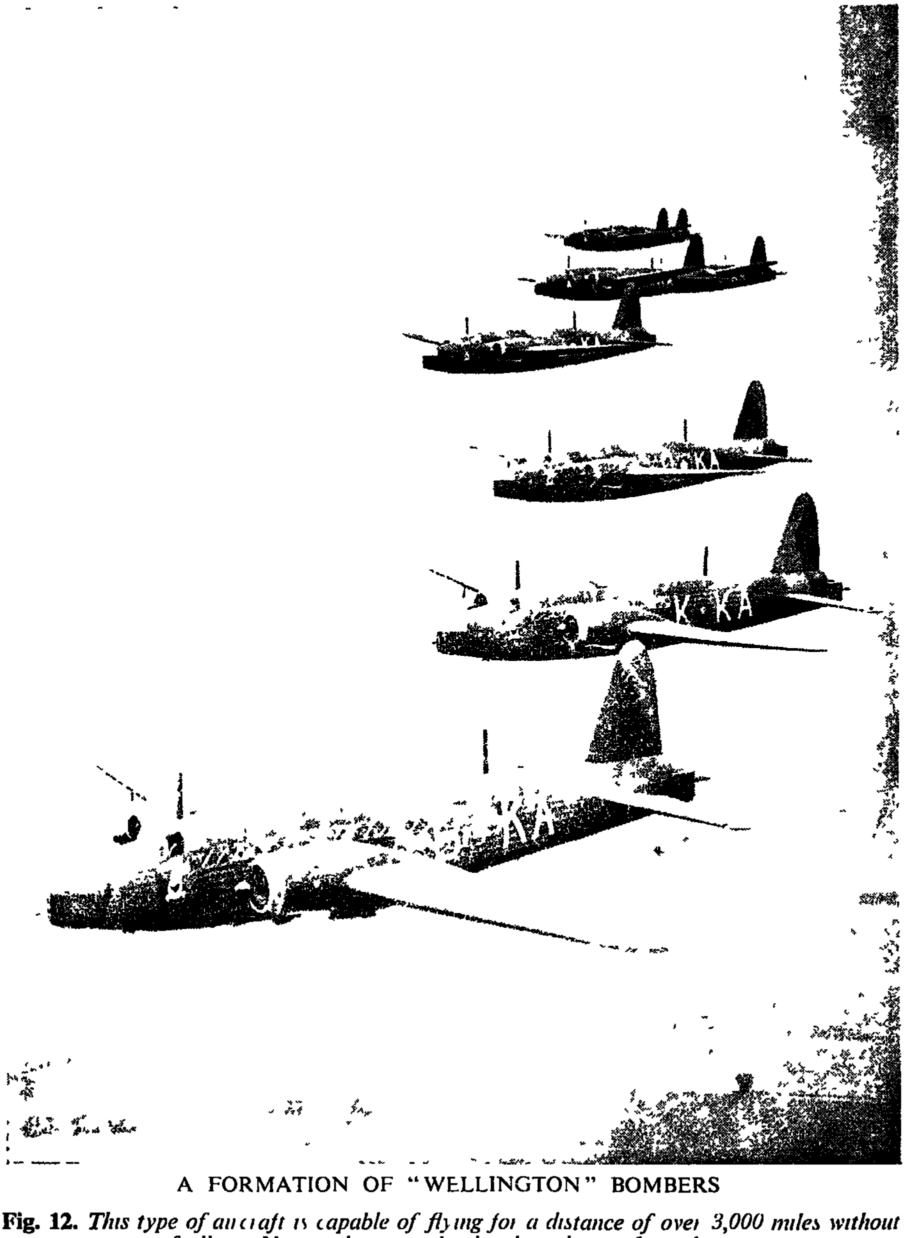
No 2 is the twin-engined Potez "63" a fast reconnaissance bomber.

No 3 is another twin-engined reconnaissance bomber-fighter, the Breguet "681," with a top speed of 300 m.p h.

No. 4 is the twin-engined Amiot "340," a high performance long-range bomber with a top speed of 295 m p h

No 5 is the Bloch "151," a single-seater fighter equipped with a Gnome-Rhône engine of 940-h.p. Its top speed is nearly 310 m p h

No. 6 is a similar fighter, the Morane-Saulnier "406." Its details are shown more clearly in Fig. 17. Powered by a




A FORMATION OF "WELLINGTON" BOMBERS

**Fig. 12.** *This type of aircraft is capable of flying for a distance of over 3,000 miles without refuelling Notice the exceedingly clean lines of its design*

Hispano-Suiza supercharged engine it can reach a top speed of 315 m.p.h.

No. 7 is a specialized fighter, the Dewoitine "D 520." A single seater with a top speed of over 325 m p.h., it is fitted with a 20-mm cannon firing through the

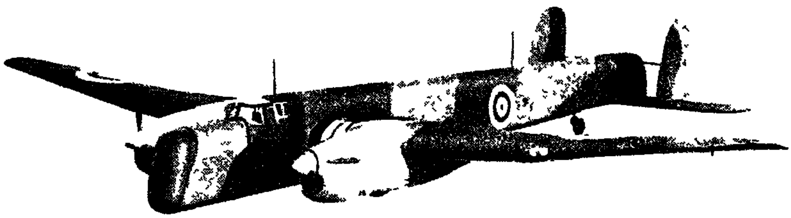


Fig. 13. *The Armstrong-Whitworth "Whitley," a long-range heavy bomber*

airscrew boss. It has astonishing climbing powers being able to reach 13,123 feet in 3 minutes 58 seconds.

No. 8 is a Dutch-designed single-seater fighter, the Koolhoven "F K 58." Powered by a 1,100-h.p Hispano-Suiza engine it has a calculated speed of 312 m p.h.

No. 9 is also a single-seater fighter, the Caudron "C 713."

No. 10 is the "C A O 200" Loire-Nieuport, another single-seater fighter.

No. 11 is a versatile and well armed bomber-fighter, the twin-engined Potez "54." With a top speed approaching 200 m p.h. it has a range of 800 miles and can carry a useful bomb load.

No. 12 is an earlier version of No. 7. It is the Dewoitine "D 510" single-seater fighter with a speed of 300 m p h.

Typical of French heavy bombers is the Amiot "142," illustrated in detail in Fig. 18. This machine has been called the "flying fortress," for in addition to its

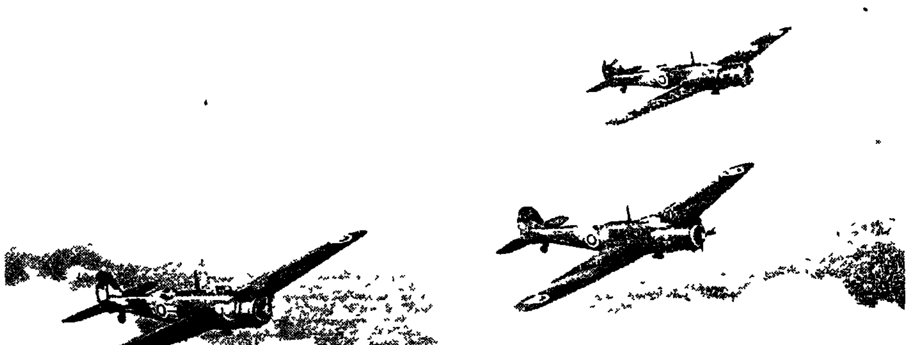


Fig. 14. *Three "Wellesley" long-range bombers flying above the clouds.*


COMPARATIVE RANGES OF TYPES OF BRITISH AIRCRAFT

**Fig. 15.** *This map shows at a glance the distances that can be flown by some types of British aircraft It must, of course, be borne in mind that if the machine has to return to its starting point without landing to refuel, the range is halved Many types of British bombers proved themselves capable of reconnaissance flights as far as Vienna and back*

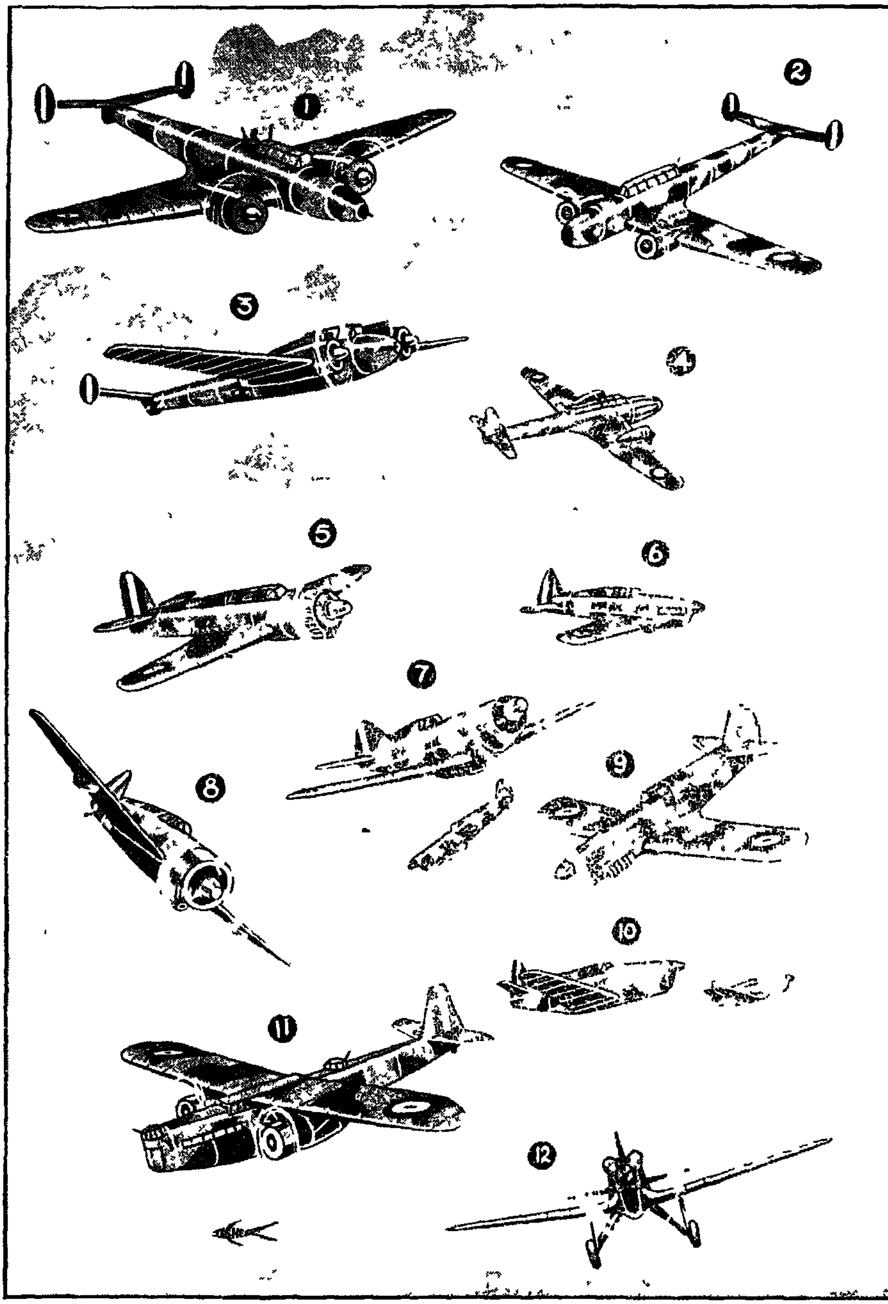


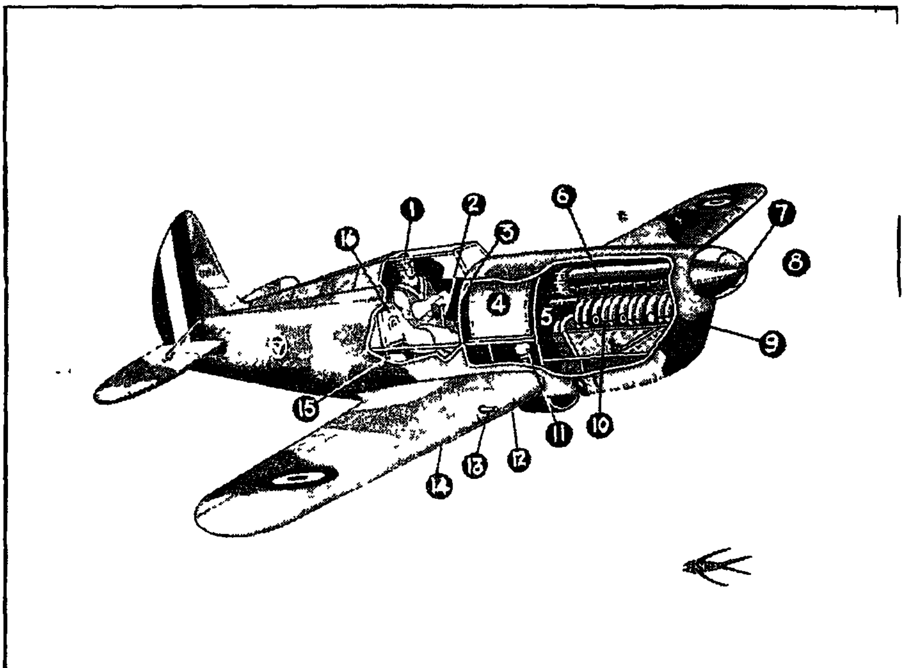
**Fig. 16.** *Types of French aircraft The key to the numbers is given in the text (page 25)*

bombs it carries four machine guns that command an enormous field of fire.

The closest co-operation exists between Britain and France in the production of aircraft Indeed, arrangements were made so that rare and expensive specialized machine tools would be available on both sides of the Channel. Despite the enormous initial start enjoyed by Germany, by February, 1940, combined production in the Allied countries had probably overhauled production in Nazi factories

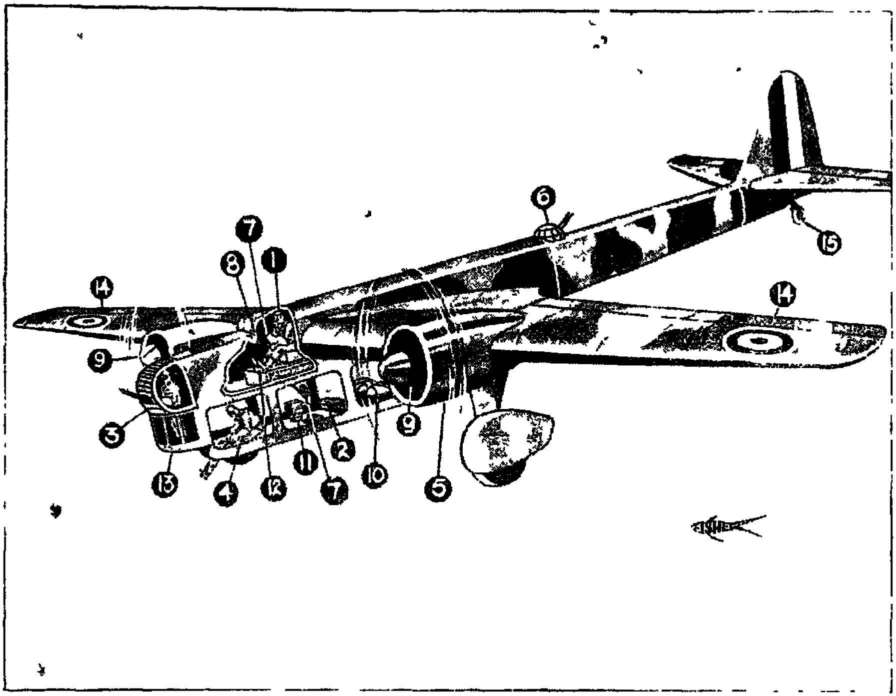
The strength of the German Air Force on the outbreak of war, was a matter for conjecture, some authorities estimating it at over 10,000 first line aircraft. Detail of the construction and performance o the machines are less indefinite

The Germans made the mistake, befor war broke out, of building up their ai force so that it consisted mainly o bombers. They built comparatively few fighters, relying on the bomber to strik terror into the heart of their enemies. So long as their enemies were relatively defenceless, the policy was sound, for b the mere threat to bomb the German were able time and again to terroriz smaller nations into submission. Their reliance on bombers was justified also in Poland, where there were few fighters to




MORANE-SAULNIER "406" SINGLE-SEATER FIGHTER

**Fig. 17.** *A French fighter with a maximum speed of 315 m p h 1, Pilot 2, Control lever 3, Instrument panel 4, Fuel tank 5, Fire wall 6, 12-cylinder glycol-cooled supercharger Hispano-Suiza 860-h p engine 7, 20-mm cannon incorporated in engine 8, Two-blad variable-pitch airscrew 9, Oil radiator in engine 10, Bronzavia flame-damping exhaus system 11, Jettison valve for petrol supply 12, Retracting ethylene-glycol radiator 13 Chatellerault machine gun (one in each wing) 14, Undercarriage retracted 15, Oxyge bottle 16 Radio This fighter had great successes against German bombers*



FRENCH AMIOT "142" HEAVY BOMBER

**Fig 18.** *1, First pilot 2, Lower second pilot's position 3, Nose gunner in turret 4, Lower forward gun 5, Lower rear gunner (aft bomb chamber) 6, Upper rear gunner 7 Control levers 8, Instrument panel 9, 780-h p Gnome-Rhône air-cooled radial engines 10, 500-kg bombs in bomb chamber 11, Aerial camera 12, Rudder bar 13 Escape trap 14 Aileron 15, Tail wheel This well-armed machine has been nicknamed the "flying fortress"*

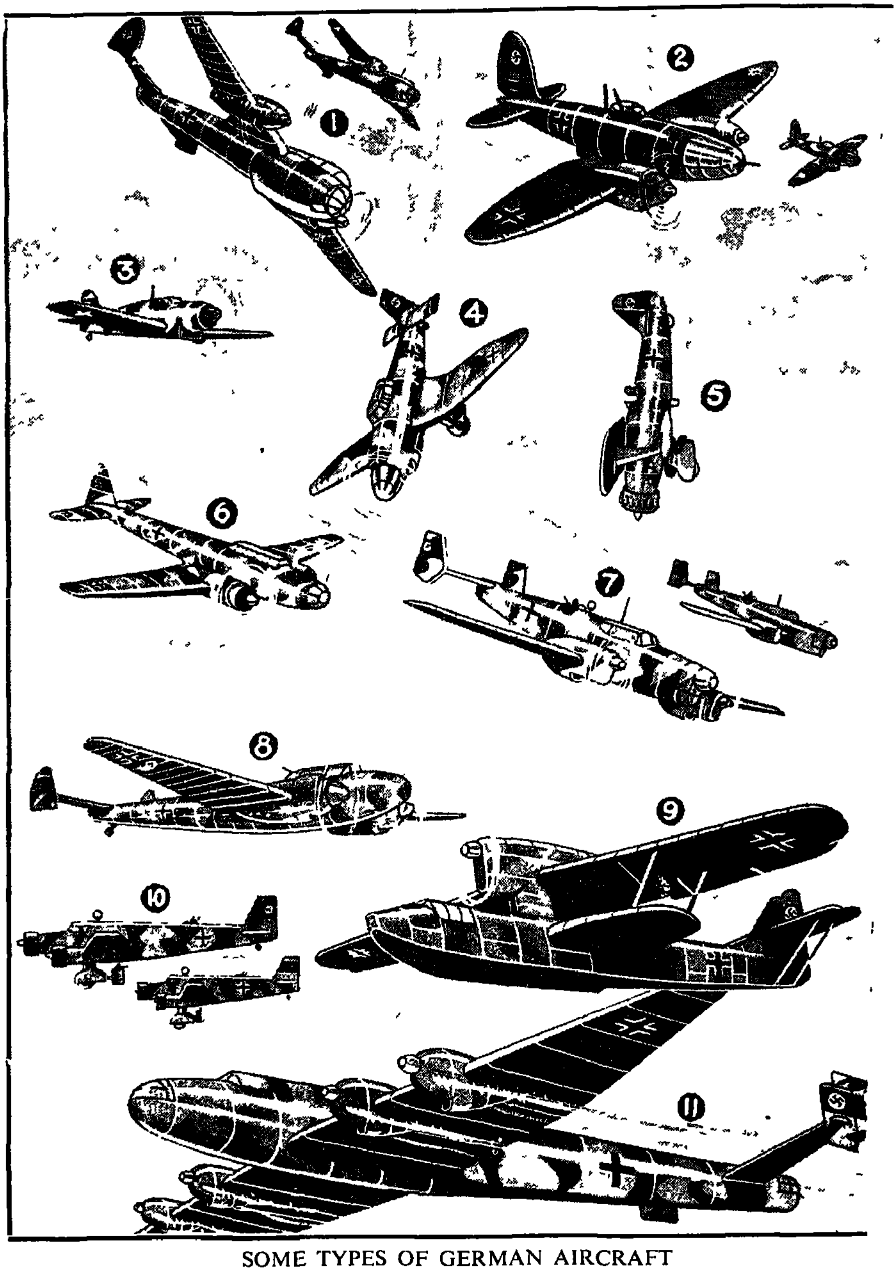
counter them. When war with the western powers broke out, however, the situation was changed, for the Allied fighters quickly demonstrated their supremacy The bomber was repeatedly driven from his course and forced to take refuge in the clouds.

### TYPES OF GERMAN AIRCRAFT

In their performance, German bombers have been disappointing and in bombing and reconnaissance flights, which the Nazis made over Britain and France in the early months, they suffered very heavy casualties.

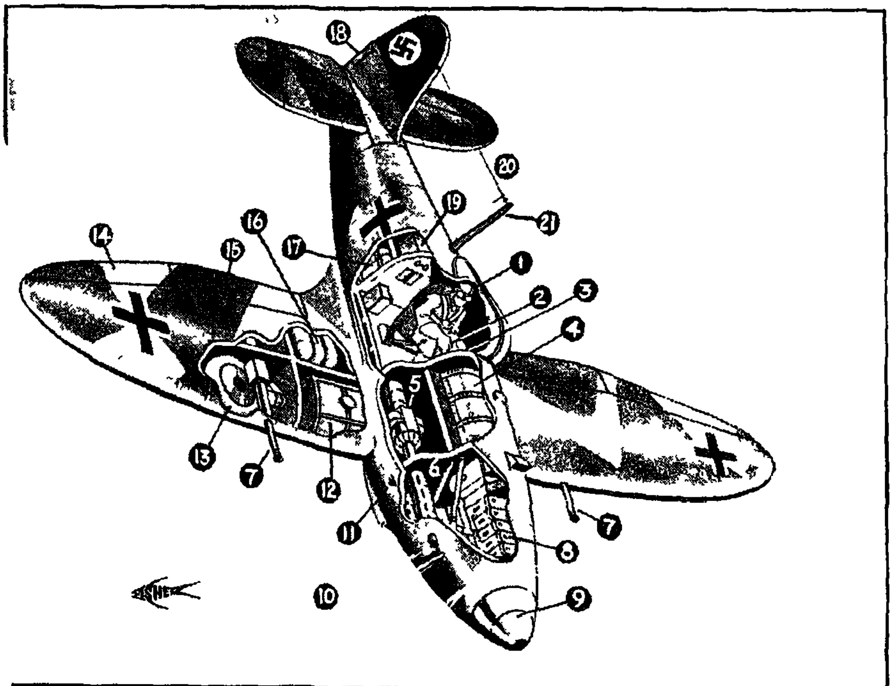
Of the principal German machines (some of which are seen in Fig. 19) the Heinkel "He 112" (shown in detail in Fig 20) is a single-seater fighter with a top speed of over 310 m p h It is fitted with two machine guns in the fuselage, and two 23-mm Oerlikon cannons in the leading edge of the wings

The major portion of the fighter section of the German Air Force is composed, however, of Messerschmitt "Me 109"s, nicknamed the "flying bricks" (Figs 21 and 22). These machines have a speed of 354 m.p h. at 12,000 feet and are among the fastest aircraft in the world A special "Me 109R" set up a new world speed record of 469·237 m p.h in April, 1939 The aircraft is undoubtedly difficult to handle. It carries two machine




SOME TYPES OF GERMAN AIRCRAFT

**Fig. 19** *1, Dornier "Do 215" bomber (early type) 2 Heinkel "He 111" bomb-*
*Messerschmitt "Me 109" single-seater fighter 4, Junkers "Ju 87" dive bomber 5, He.*
*"Hs 123" single-seater dive bomber (Diesel engines) 6, Junkers "Ju 88" bomber 7, Jur*
*'Ju 86K" bomber (Diesel engines) 8, Messerschmitt "Me 110" twin-engined fighter,*
*Dornier "Do 18K" flying boat. 10, Junkers "Ju 52" bomber. 11, Junkers "Ju 89" bon*




GERMAN HEINKEL "He 112" SINGLE-SEATER FIGHTER

g. 20. *This fighter with a top speed of over 310 m p h is not as fast as the "Hurricane"* *Pilot 2, Control lever 3, Instrument panel 4, Fuel tanks (giving range of 685 miles at '6 m p h ) 5, Machine gun 6, Fire wall 7, Oerlikon cannons 8, 1,160-h p Daimler-Benz gine 9, Spinner 10, Three-blade variable-pitch airscrew 11, Exhaust outlet 12, Fuel nk 13, Retracted undercarriage 14, Aileron 15, Flap 16, 10-kg bombs 17, Oxygen bottles 18, Rudder trimming tab 19, Radio 20, Aerial 21, Aerial mast*

uns in the wings, firing outside the dius of the airscrew, and two synchro-zed machine guns fitted in the trough ove the engine cowling. It may also .ry a 23-mm. cannon, firing through e boss of the airscrew at 500 rounds per nute with a shell velocity of 2,400 feet r second.

On the whole, the performance of the ·sserschmitts must have disappointed e Germans, for the "Me 109" four-gun ghters failed to engage British bombers i·h any great success In one British on German warships off Heligoland ly two out of twenty German fighters ghted attempted to attack and both were driven off by the bombers' fire, one being shot down This contrasts strikingly with the performances of the British fighters that have so successfully engaged German bombers and reconnaissance machines.

It is significant that after five months of aerial warfare, over twice as many German fighter aircraft were destroyed as any other type On the other hand, during the same period not a single British fighter was shot down by a German bomber in Great Britain or home waters.

Early in December, 1939, the Germans began using a new version of the

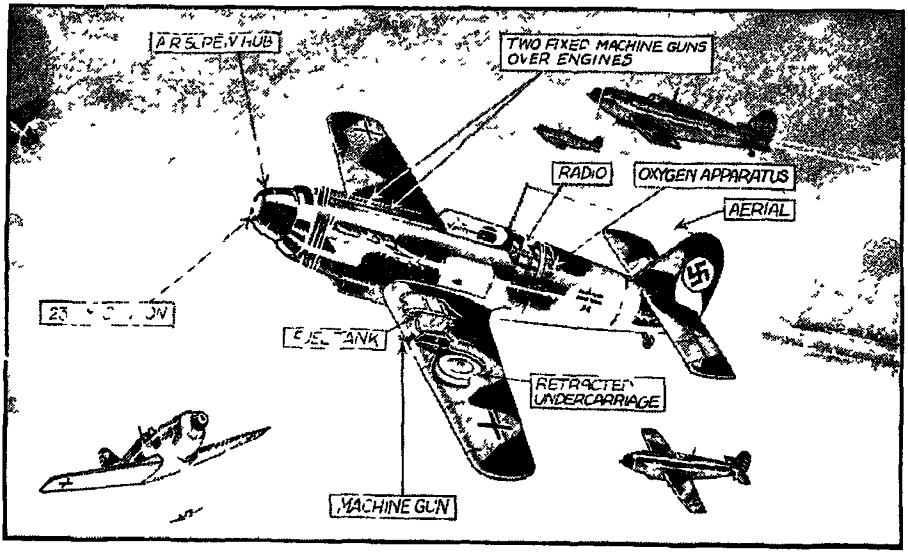
Messerschmitt, the "Me 110" This is designed (Fig. 23) like the British "Defiant," as a long-range fighter. Despite twin engines, however, they are no faster than the "Spitfires," having a top speed of 365 m p h at 16,500 feet. Their armament consists of two forward firing cannon and four machine guns The cannon are fixed in the nose of the aircraft under the pilot and fire a three-quarter-inch shell with an effective range of 600 yards Of the machine guns, two are fixed and two are movable in a gunner's turret at rear The fuel tanks, mounted in the wings, hold 400 gallons of petrol and give them a range of 1,700 miles at 160 m p h. These fuel tanks, incidentally, are wonderfully designed, being almost leak proof, fire proof, and crack proof

"Me 110"s were first tried out when British bombers raided the Heligoland Bight on December 18, 1939, and again in action over the North Sea on January 2, 1940 One or two probably reached the British coasts on experimental flights in a number of raids.

**WEAK SPOT OF THE "Me 110"s**

The "Me 110" has not proved a great success. Despite its great advantages in speed and armament, it suffered severely at the hands of British bombers Generally, these machines endeavour to approach a bomber from a point which the latter's guns cannot cover They seldom close to point-blank range, relying on the extra range of their cannon, but in banking as they turn away they invariably present their comparatively large and undefended surfaces to the bombers' gun crews—and many of them have paid the penalty.

The pride of Germany's air fleet is her bomber, and undoubtedly she has produced some very fine machines The




GERMANY'S LEADING SINGLE-SEATER FIGHTER

**Fig. 21** *The Messerschmitt 'Me 109,' a single-engined fighter is capable of over 350 m p h It is armed with four machine guns and a 23-mm cannon through the hub of the airscrew. This machine, the leading German single-seater fighter, is exceptionally fast, but is neither so fast nor so easy to handle as the "Spitfire"*

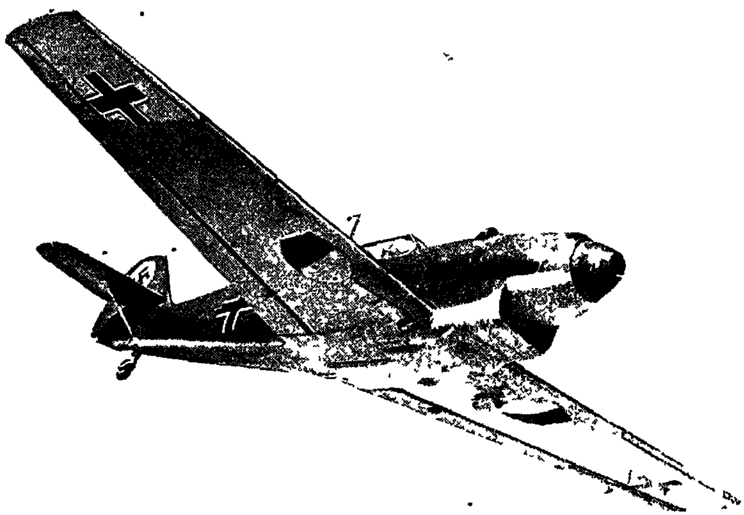


**Fig. 22.** *Nicknamed the "flying brick"—the Messerschmitt 'Me 109' single-seater fighter*

Junkers "Ju 87" (Fig 24) is a dive bomber that was employed extensively in the Polish campaign Its bomb load can be varied. One 1,100-lb bomb and four 110-lb. bombs can be carried, or the load can be reduced to five 110-lb. bombs.

In addition to its load of bombs, four of which are carried beneath the wings, it is armed with machine guns in the leading edge of each wing A dive bomber may commence its dive at a height of 10,000 feet, the aiming dive being made at a steep angle The aircraft thus attains a tremendous speed, to counteract which "air brakes" are fitted to both main wings, just behind the leading edge, for use when pulling out of the dive. These air brakes are in the form of "slats" set in the wings edge-on to the air stream in normal flight, but adjusted when in use through ninety degrees so that they act as brakes.

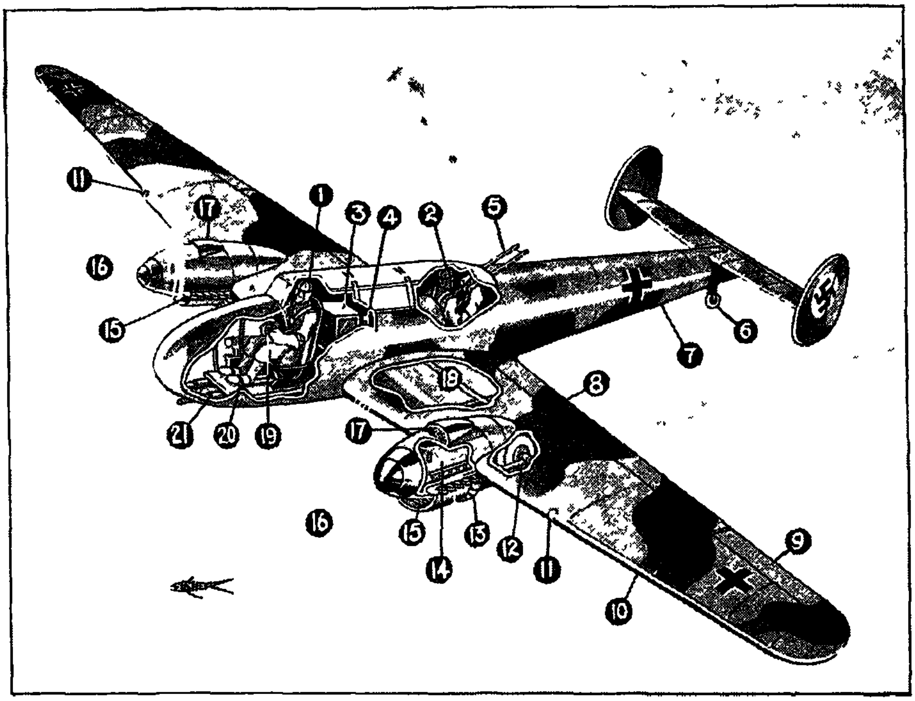
Beneath the fuselage is a fork that deflects the bombs from contact with the air-screw when they are released on a steep dive The bombs are released as the machine is pulled out of its dive at a height of about 1,000 to 3,000 feet

Other German bombers include the Junkers "Ju 86" (Figs 25 and 26) fitted with Diesel engines, the "Ju 88," one of the world's fastest bombers with a cruising speed of over 300 m p h and a range of over 1,200 miles It possibly appeared over Britain in the Scapa raid of March, 1940 The "Ju 89," fitted with four engines, can be used for troop transport as well as for bombing

### THE "FLYING PENCIL"

The Dornier "Do 215" (Fig 27), a very powerful machine, succeeded the "Do 17" nicknamed, because of its shape, the "flying pencil" (Fig 28) This machine, which was very successful in the Polish campaign, also appeared in one or two of the early raids on Britain

Having described some of the principal types of bomber and fighter aircraft,




GERMAN MESSERSCHMITT "Me 110" TWIN-ENGINED FIGHTER

**Fig. 23.** *This "destroyer plane" may be used to accompany and protect bombers on their flights 1, Pilot 2, Rear gunner and wireless operator. 3, Radio 4, Oxygen bottle 5, Twin machine guns 6, Non-retractable tail wheel 7, Stressed-skin fuselage 8, Slotted flaps 9, Slotted ailerons 10, Automatic slots. 11, Landing light. 12, Retracted undercarriage 13, Controllable radiator gills 14, Daimler-Benz engine. 15, Radiator 16, Three-blade controllable-pitch airscrew 17, Oil cooler. 18, Port fuel tanks (others in starboard wing) 19, Control lever 20, Rudder bar 21, Twin 20-mm cannon.*

we can now turn our attention to the practical side of aerial warfare. First the work of the fighter pilot. This is of two sorts—the one, action against enemy fighters, and the other, action against enemy bomber aircraft

### TACTICS OF FIGHTER PILOTS

Different tactics are involved in the two classes of fighting, and the single-seater fighter pilot will use different tactics from the pilot of a multi-seat or of a twin-engined fighter Then again, the tactics used by a fighter pilot vary with the armaments that his aircraft carries.

In a single-seater fighter, such as the "Hurricane" or "Spitfire," it is obvious that the pilot—whose hands and feet are busy operating the flying controls—is unable to operate and sight a movable machine gun. His guns are therefore fixed. Instead of aiming his guns, the pilot aims his machine at the enemy (Fig. 29). A fixed sight (2 and 3, Fig. 29) mounted in front, shows him when the enemy aircraft is within the area of fire. All eight guns operate simultaneously when a trigger (1, Fig. 29)—mounted on the control column—is pressed.

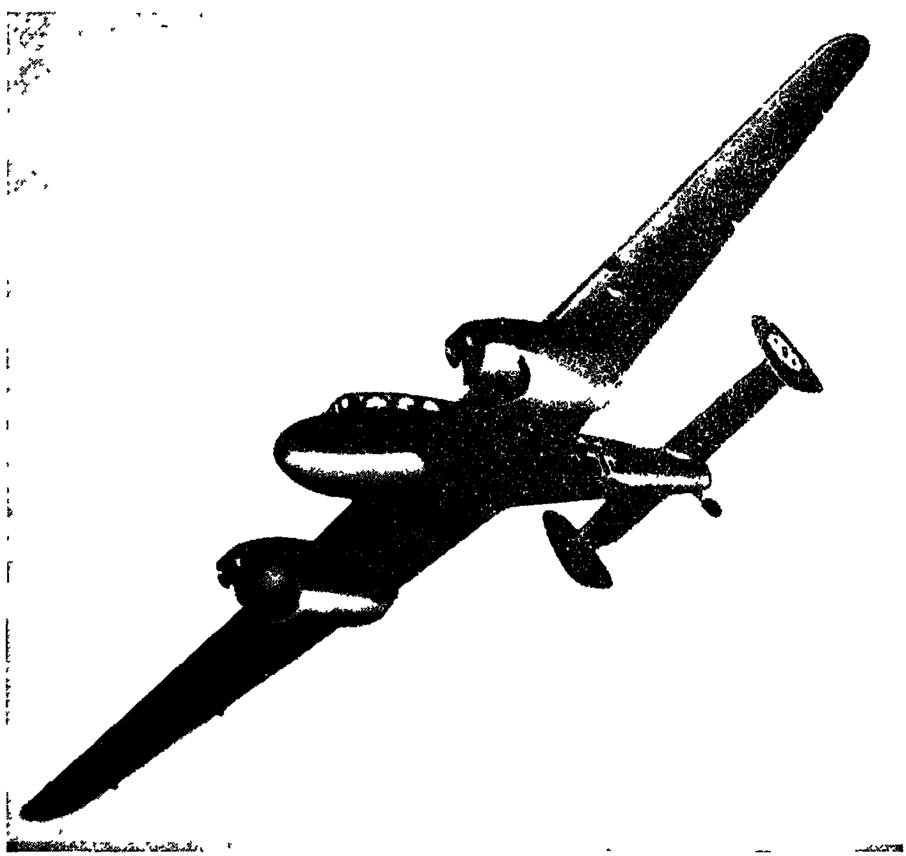
The guns do not all fire directly ahead, but are set so that the bullets from them converge to a point about two hundred

yards ahead of the aircraft. The damage done by many bullets smashing close together into the frame of an aircraft is sufficient even to break very strong girders. It is, in effect, similar to the action of a giant circular saw and is virtually capable of cutting aircraft in half. Thus, the holes caused by converging guns can bring an aircraft down, whereas fifty bullets passing through the aircraft at different points might cause only superficial damage.

The damage caused by bullets from converging guns is comparable with that produced by aircraft "cannon " German fighters are equipped with a cannon as well as with one or two machine guns The former may fire through the boss of the airscrew as in the "Me 109" (Fig 21), or be mounted separately beneath the cockpit as in the "Me 110" (Fig 23).

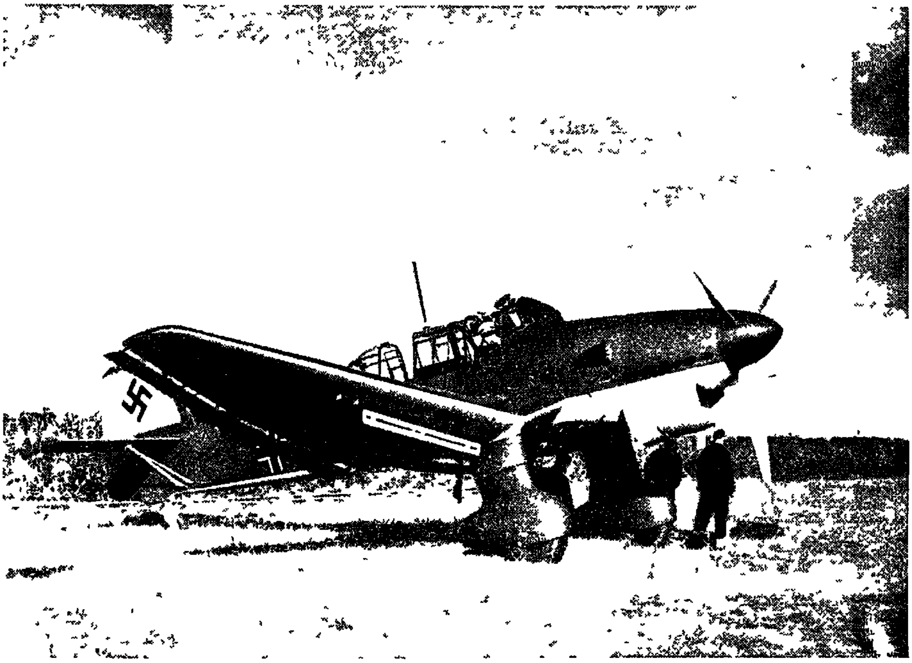
### CANNON AND MACHINE GUNS

Advantages of the cannon are that it can be used at greater ranges than the machine gun, and that the damage caused by the explosion of the shells is considerable, a single hit being almost certain to bring down a machine Against this is the fact that accurate sighting of guns in a fast



A GERMAN LONG-RANGE FIGHTER—THE "Me 110"

*The Messerschmitt "Me 110," powered by two Daimler-Benz engines can exceed 360 m p h. Its fuel tanks hold 400 gallons and its range is 1,700 miles at 160 m p h*



GERMAN JUNKERS 'Ju 87' DIVE BOMBER

**Fig. 24.** *This type of machine was used extensively in the Polish campaign In addition to its load of five 110-lb bombs, it has machine guns in the leading edge of each wing Note the streamlining of the wheel coverings*

moving modern fighter is difficult at any-thing like long range. Moreover, the faster rate of fire of machine guns is more likely to prove effective than the slower fire of cannon It is possible, however, that as a result of rapid improvements cannon will prove a more suitable weapon than the machine gun for the fighter.

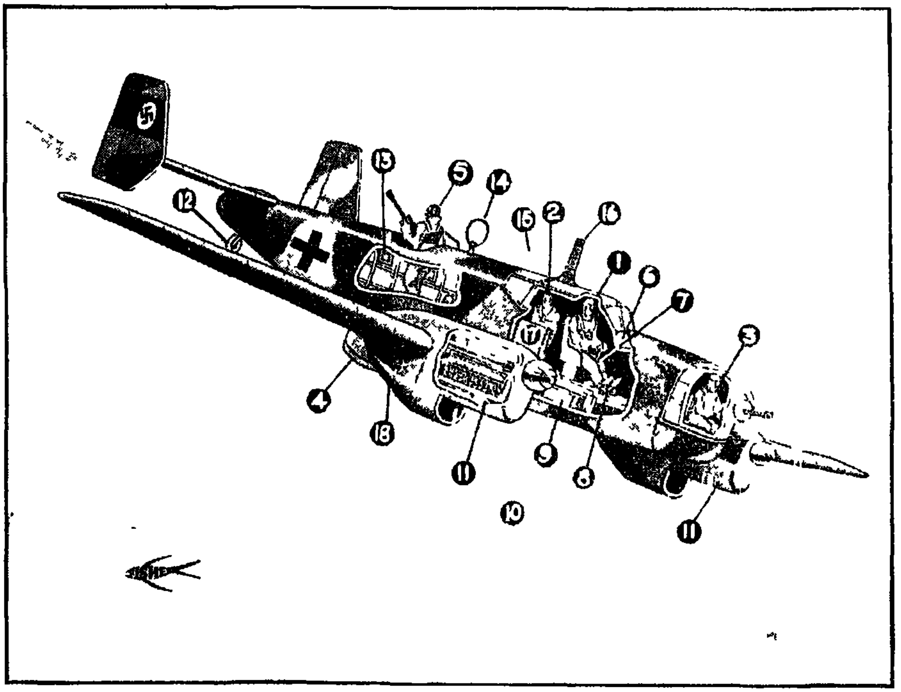
We may here mention an interesting point in regard to machine gun fire. At regular intervals, say every third or fifth bullet, the machine gun of a fighter air-craft is fed with what is called a tracer bullet. These bullets burn as they pass through the air and give off smoke, so that they are visible to the pilot both at night and in the daytime The object of using them is to enable the pilot to see where his bullets are going, thus enab-ling him to correct his aim accordingly

One of the great inventions of the war of 1914-18 was the synchronization of engine timing and machine gun, by which it was possible to fire through the blades of the airscrew without the bullets dam-aging them A similar, though improved, device is used today (Fig. 30) whenever guns are so mounted that they are re-quired to fire through the blades of the airscrew. Two cams actuated by the engine work in the generators of a closed oil circuit, and the "push" of these cams set up pulsations or wave motions in the oil pipes. This communicates a similar impulse to the firing mechanisms of the guns and in this way controls the fire, allowing bullets to leave the guns only when they are assured of a clear passage between the airscrew blades

Since the single-seater fighter pilot can

only fire ahead, his chief concern—either when he is engaging other fighters or is attacking bombers—is to manœuvre so that the enemy is ahead of him. While endeavouring to get his enemy in front of him he must also manœuvre so as to prevent any other enemy aircraft getting behind him, for his most vulnerable point is the rear of his machine. That is why skill in aerobatics is of such importance to the fighter pilot It also explains why formations of fighters, when they meet, soon break up into individual fights between two or perhaps three aircraft (bottom Fig. 31)

Height at the beginning of a "dog fight" between fighters may easily prove the deciding factor The aircraft that are higher have the advantage of greater speed when they dive on the enemy fighters, and have thus a better chance to "get on to their tails " The attacking aircraft will open fire on the aircraft below them as soon as the distance is close enough If the lower aircraft have been taken by surprise—because, for instance the diving aircraft had the sun behind them (see inset Fig. 31) some may fall to the guns of the diving aircraft before they can manœuvre out of the way Thereafter the pilots of the diving aircraft will each select an opponent and endeavour to keep on his




GERMAN JUNKERS "Ju 86" HEAVY BOMBER

**Fig. 25.** *A large German bomber powered by Diesel motors 1, Pilot 2, Wireless operator 3, Forward gun and bomb aimer 4, Lower rear gunner in retractable gun turret 5, Upper rear gunner 6, Instrument panel 7, Control lever 8, Rudder bar 9, Automatic pilot. 10, Variable-pitch airscrew 11, Junkers "Jumo 205" Diesel motor (510-600 h p ) 12, Tail wheel 13, Ammunition 14, Directional wireless loop aerial 15, Aerial 16, Aerial mast 17, Radio 18, Undercarriage retracted*

tail until he is able to get the enemy machine within the gun sights.

In the dog fights of the war of 1914-18 the endeavour of pilots to keep on each others' tails, often led—with their slower machines—to their chasing one another round and round in a tight circle as shown at A in Fig. 32. In this position neither pilot could bring his guns to bear on the other. Each endeavoured to catch up on the other by tightening the circle. If one could catch up, as at B, his opponent would lie within his line of fire, but it was impossible to do this because it would necessitate the circle being tightened to a point at which the pursuing aircraft would stall or side-slip

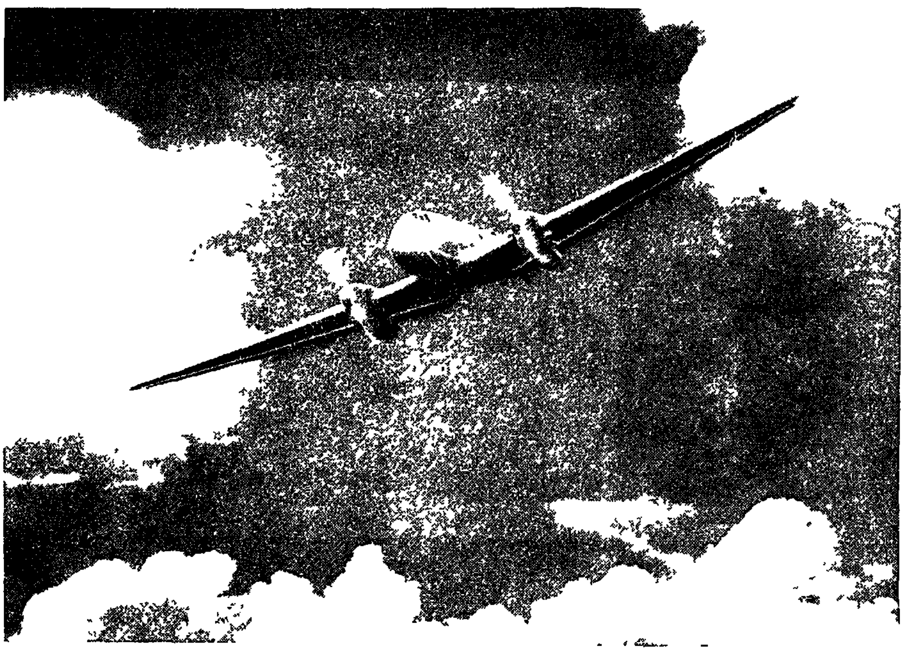
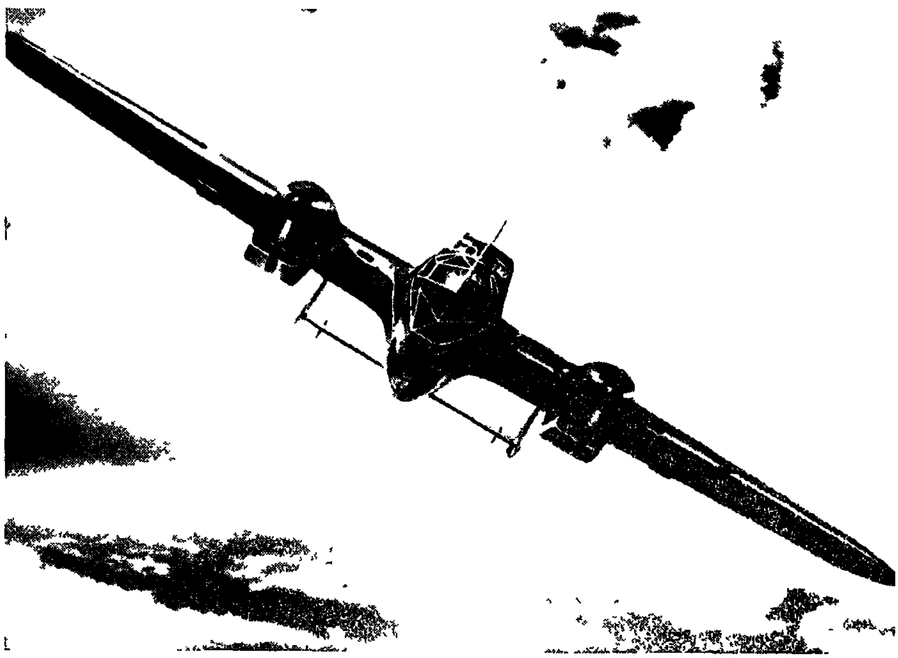


Fig. 26. *German Junkers "Ju 86" heavy bomber in flight*

If the pilot in front broke out of the circle it is obvious that he would immediately come within the range of the guns of the pursuing aircraft. Such positions of stalemate could sometimes be broken up only by the intervention of a third aircraft.

With modern fighters, because of their very high speeds, such circling is unlikely. If close turns are made at high speeds in a modern fighter the effect of centrifugal force on the blood of the pilot, throws considerable physical strain on him. If a steep turn is entered too suddenly the pilot may lose consciousness.

A fighter pilot who has another close on his tail will execute many forms of aerobatic manœuvres to shake off the following pilot, who will endeavour to follow his opponent exactly in all these manœuvres so as to maintain his advantage But there must be a lag, even though it be only a fraction of a second, between the time at which the front pilot begins a manœuvre and the time the following pilot realizes what that manœuvre is. The greater the speeds of the aircraft the further they will move apart during this lag in time and the greater will be the chances of the leading pilot



A GERMAN HEAVY BOMBER—THE DORNIER Do 215

**Fig. 27.** *This powerful machine, fitted with Diesel engines, is an improvement on the Dornier "Do 17" illustrated below. Notice the effective use of streamlining and the retracted undercarriage. Bullet-proof petrol tanks are another feature.*

DORNIER "Do 17"—THE FAMOUS FLYING PENCIL

**Fig. 28.** *Nicknamed, because of its peculiarly slim construction, the "flying pencil," this long-range German bomber appeared on several reconnaissance flights over Britain in the autumn of 1939. These aircraft were no match for British fighters.*

BELT OF BULLETS

*Loading belts of ammunition into a Spitfire fighter to feed its eight machine guns*

getting away. For this reason, individual dog fights occur less frequently today.

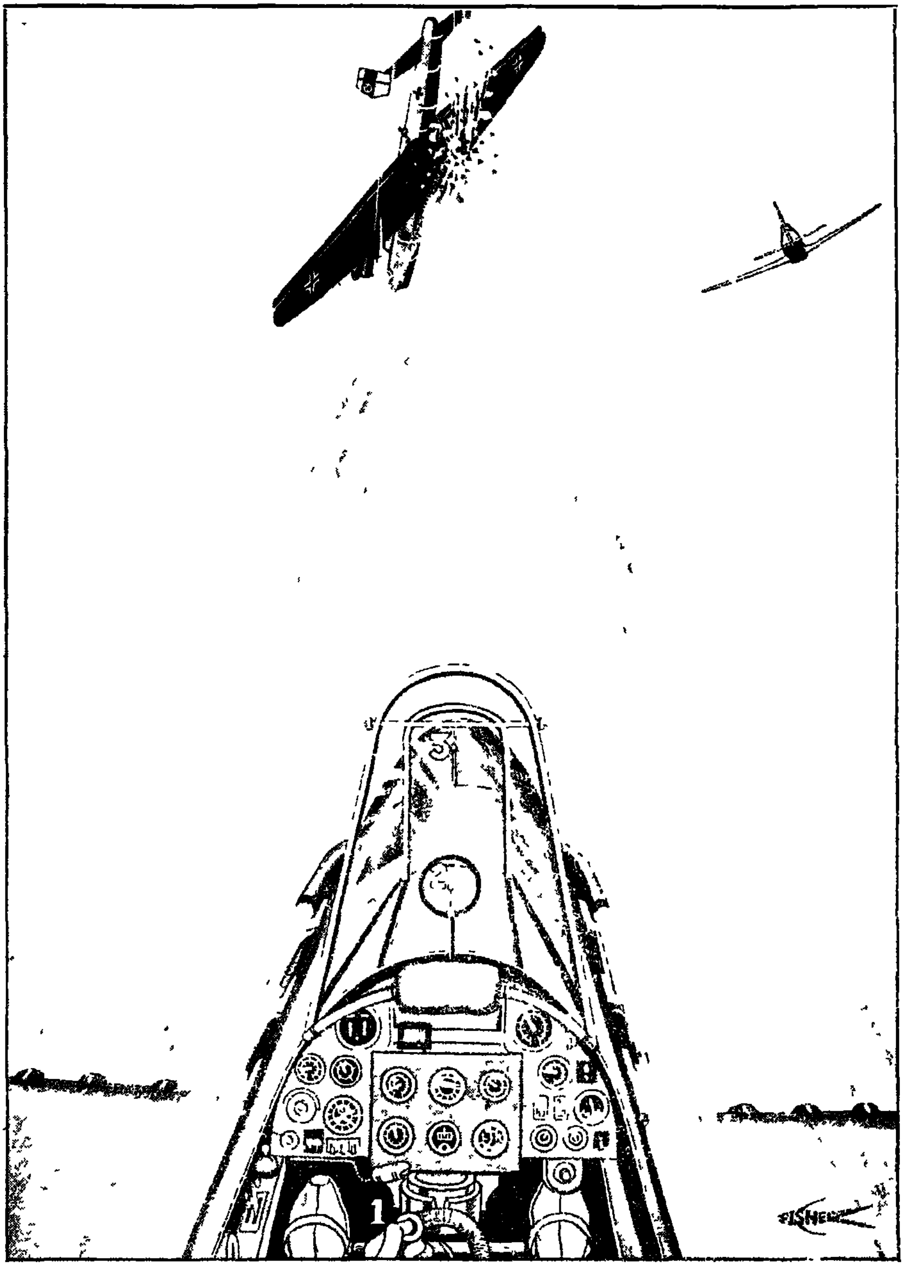
In carrying out the high-speed dives on any enemy aircraft that is below, great skill is needed The pilot must begin to pull out of the dive in time to avoid flying into the aircraft below, but at the same time he must be close enough for effective fire at the moment his guns bear.

When dealing with bombers, the tactics employed by fighter aircraft are different The bombers, especially when fully loaded with bombs, are not as fast as the fighters, which can overhaul them easily, nor are they so manœuviable. On the other hand, they are more heavily armed and have movable guns that can be trained on the fighter from almost any angle

The aim of the fighters is to destroy or turn back the bombers before they reach their objective The fighters may be in the air on patrol when the bombers are spotted, or they may be on the ground waiting for word from listening posts.

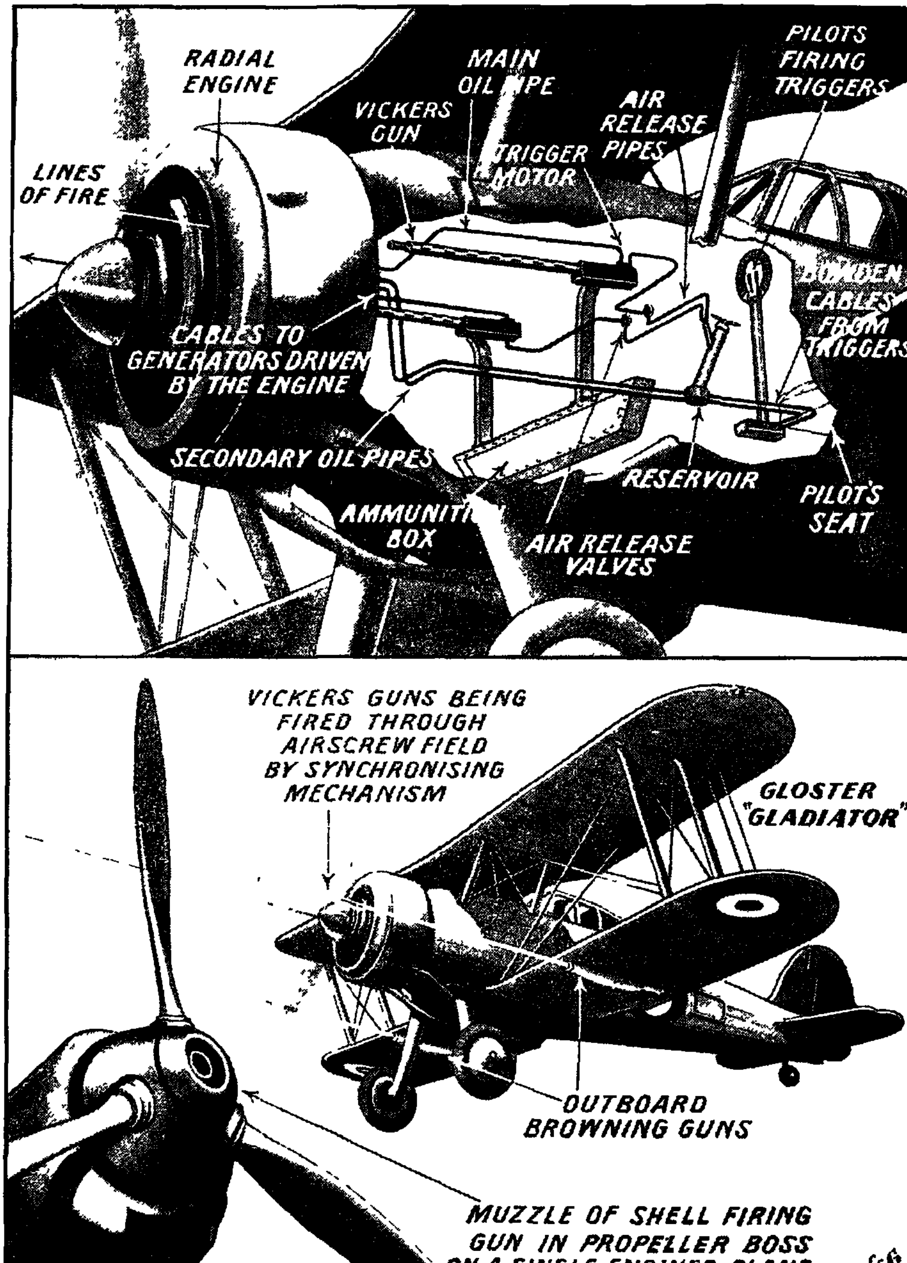
BATTLE SCARS OF A BOMBER

*A smiling R A F officer examining the effect of British machine gun fire on the fuselage of a German bomber shot down by fighter aircraft in Scotland in December, 1939*



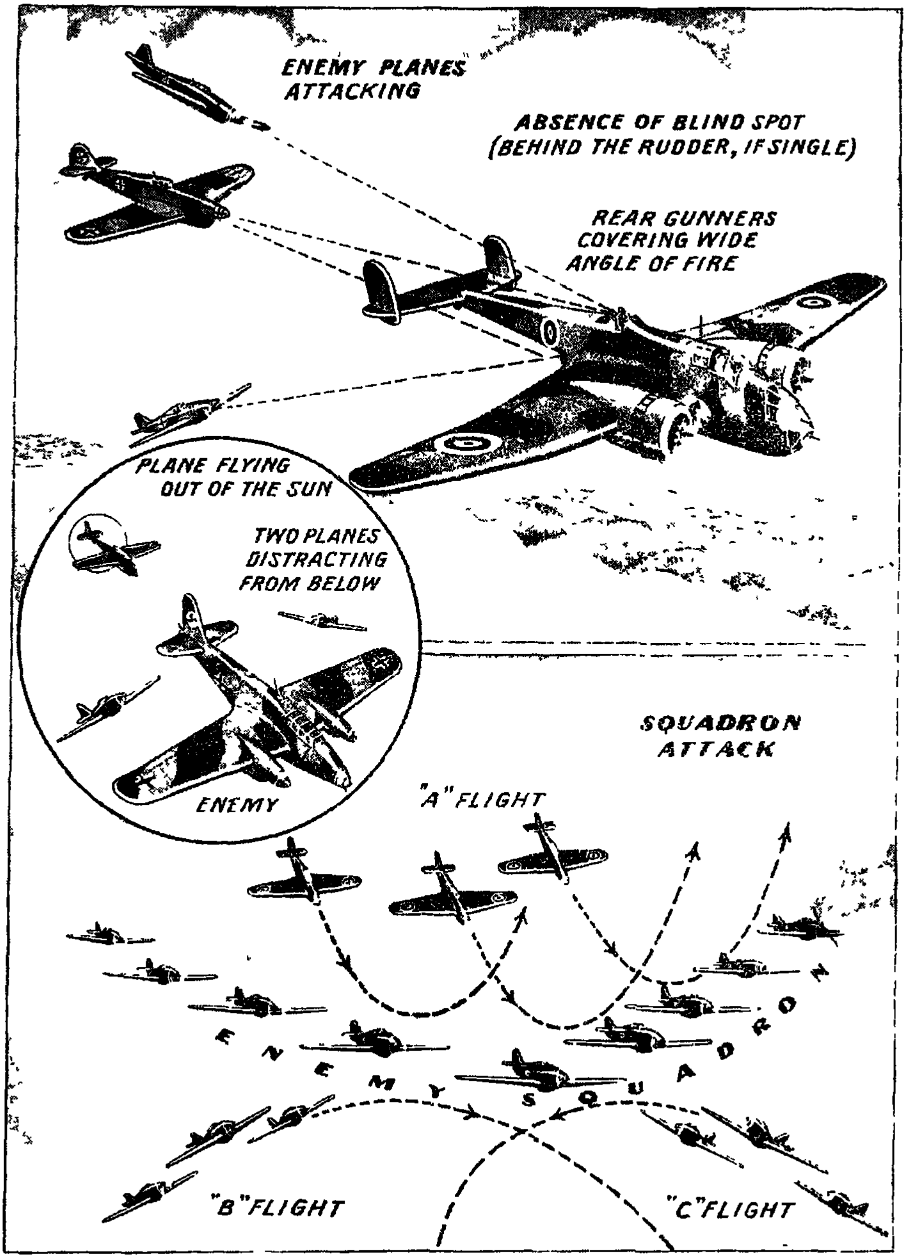

HAIL OF CONVERGING FIRE FROM AN EIGHT-GUNNED FIGHTER

**Fig. 29.** *This picture shows how the fire from all eight guns of a single-seater fighter converges The guns are operated by pressure of the trigger (1) The back ring sight (2) and the forward bead sight (3) show the pilot when the target is within his field of fire.*




FIRING A MACHINE GUN THROUGH THE AIRSCREW

**Fig. 30.** *Details of mechanism synchronizing machine gun fire with engine revolutions, thus enabling bullets to pass through the field of the revolving airscrew (For explanation see text) Cannon are frequently fixed to fire through the airscrew boss (below, left)*




ATTACK AND DEFENCE IN THE AIR

**Fig. 31.** (*Top*) *A rear gunner's area of fire on a typical British bomber the "Hampden"* (*Inset*) *How a flight of fighters makes use of the sun in attacking* (*Below*) *Simplified diagram showing the tactics used by one fighter squadron in attacking another squadron of fighters*

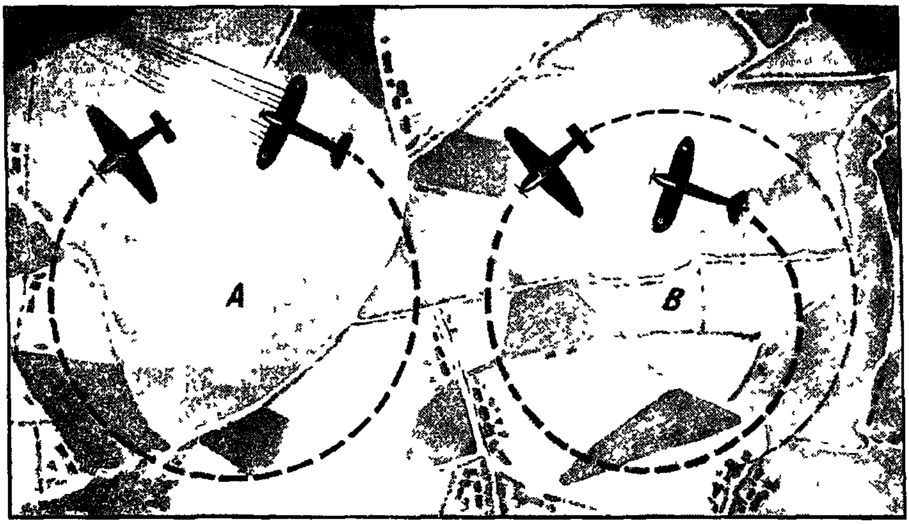



**Fig 32.** *Diagram of "dog fight"* (*For explanation see page 40.*)

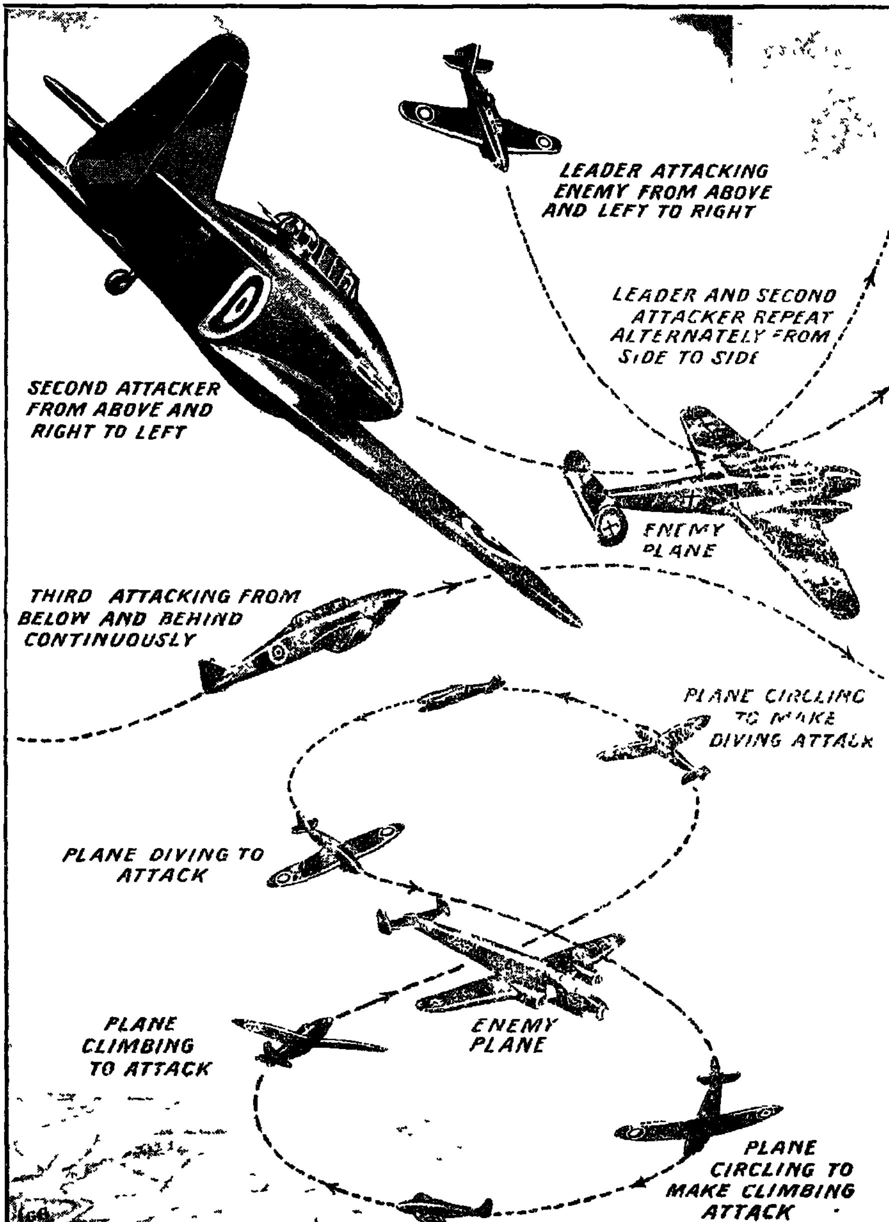
(The illustration on page 17 shows a typical "Spitfire" on patrol.) Great speed and terrific power of climb are necessary in the intercepter fighter, for a few minutes lost in contacting the bombers may mean that they will be able to reach their objective. The height at which long-range bombers usually operate is 10,000 feet, and an intercepter fighter must be able to climb to this height in about four minutes.

Suppose that the bombers manage to get through without being spotted by the fighters and thus gain a start of three minutes only. If the bombers are travelling at 240 m.p.h. and the fighters at 336 m.p.h.—both conservative speeds—then the bombers will be able to cover forty-two miles before the fighters catch up with them.

It will be appreciated that the fighter pilot must fly accurately on the correct bearings when contacting the bombers, and in this he is helped by radio. The leader of a squadron, or the leader of a flight, is always in two-way radio-telephonic communication with his aerodrome, and also with the other members

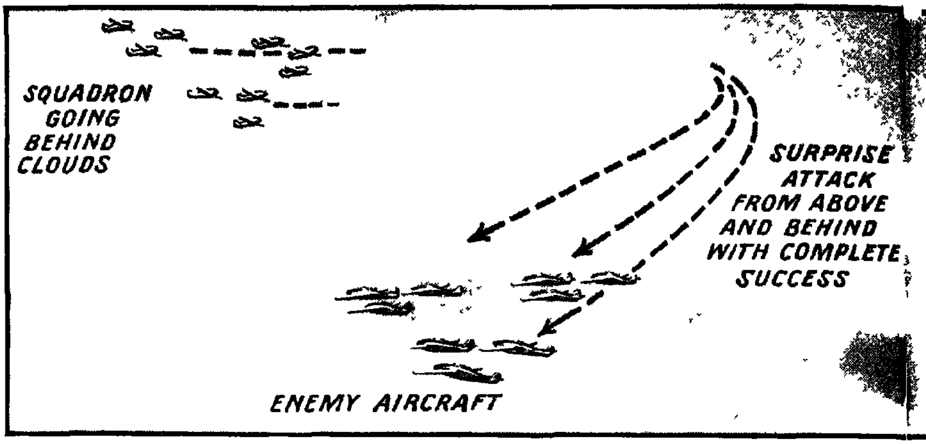
"OVER TO YOU"

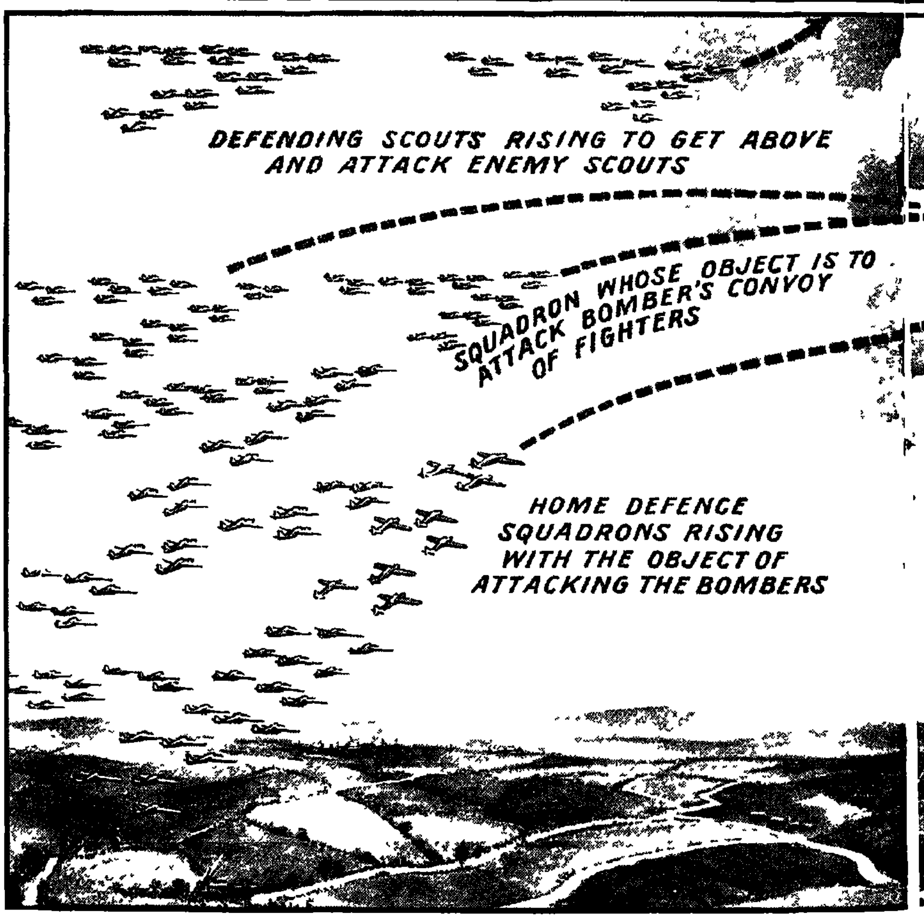
*British pilots can always communicate with their aerodrome by means of radio-telephony. Here a bomber pilot is seen speaking into the microphone fixed to his oxygen mask. The switch is seen under his right hand.*



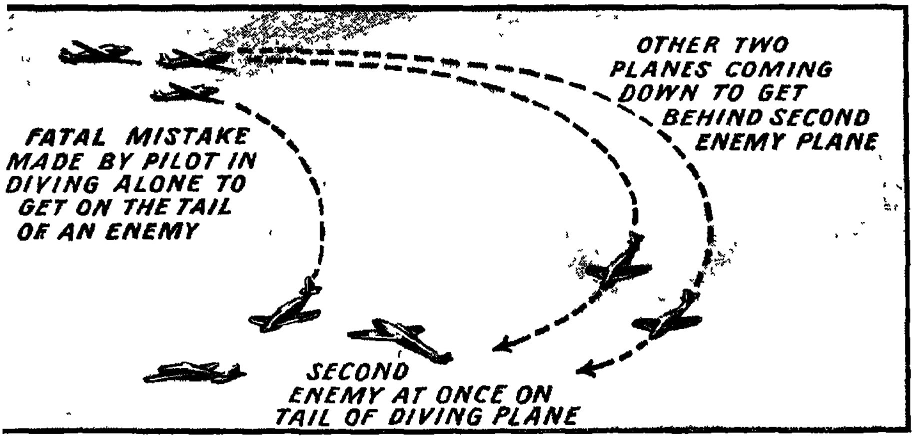

STRATEGY OF FIGHTER ATTACK

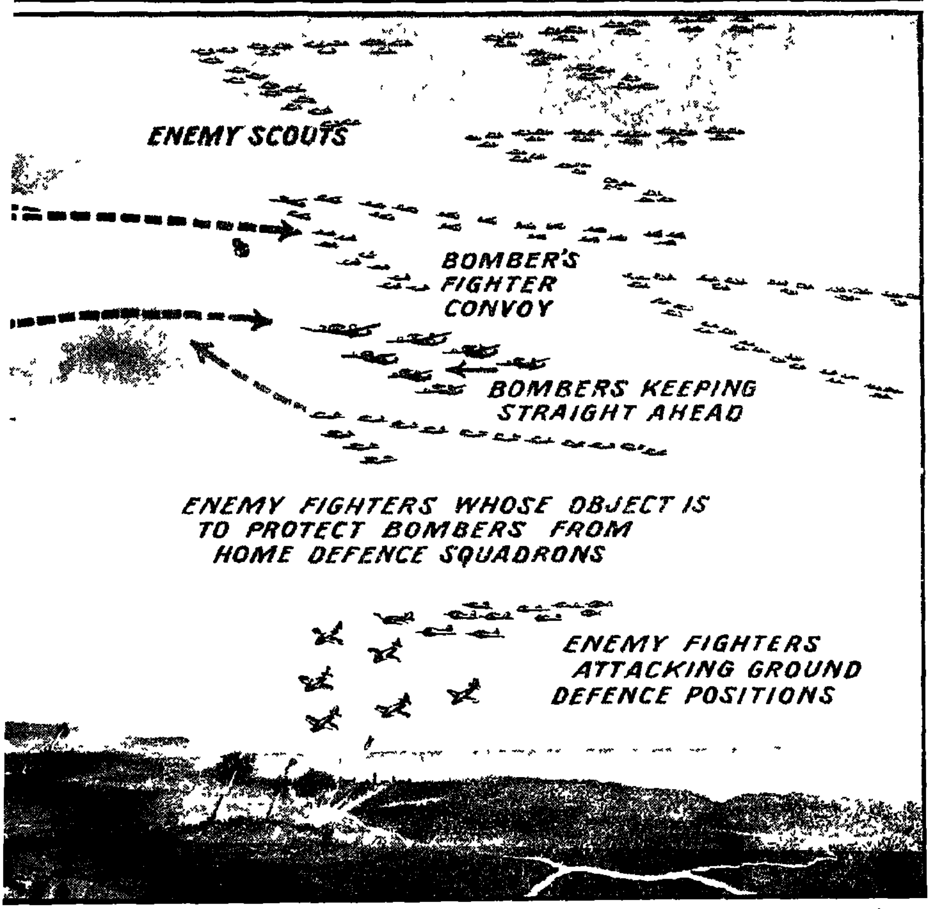
**Fig. 33.** (*Top*) *How a flight of three fighters attacks an enemy bomber Two of the aircraft attack on either side from above, swooping down and across the enemy, while the gunners rake him with fire The third aircraft harasses by attacking continuously from below and behind* (*Below*) *How a single machine describes 'figures-of-eight' in attacking an enemy*




(*Top*) *Some manœuvres of fighter aircraft when attacking* (*Below*) *An enemy bomber*




*squadron with attendant scouts and fighters about to be engaged by Home Defence squadrons*

of his formation. Radio-telephony is used to save time. The illustration on page 46 shows a pilot in touch with headquarters.

While climbing to make contact with bombers the fighter pilot has many things to do In addition to keeping formation (and in attacking bombers, fighters keep very close formation) and maintaining a correct course, which each pilot must note individually in case he has to return by himself, the pilot has many other things to keep him occupied He has to pay attention to radio communication, attend to the operation of his retractable landing gear, watch the temperature and boost-pressure gauges of his engine, and check over the oxygen supply that he has to use when operating at great heights

Having made contact with the bombers, the fighters use one of a number of methods of attack. For instance, having obtained a favourable position above the bomber or bombers, the flight of fighters breaks formation. The leader dives on the bomber, getting in a burst of fire as he passes it He is followed down in a slightly different direction first by one of the other aircraft and then by the second (the method is illustrated in Fig 33). The three aircraft sometimes pull out of their dive below the bomber and zoom up one after the other, getting in further bursts of fire as they again pass the enemy bomber.

### VALUE OF REAR GUNS

The gun in the tail of a bomber is the most dangerous to the fighter If this can be put out of action, one fighter can get behind the bomber and attack it in much the same way as he would attack another fighter Bombers being slower and heavier are much less manœuvrable than fighters, and once a bomber is caught in this way, unless his rear gunner can bring down the chasing plane, he is in danger of having his tail shot away In any event, the tail is the most vulnerable part of a bomber and a high degree of courage and skill is called for in the rear gunner. On the accuracy of his shooting very often depends the lives of all the bomber's crew He is exposed to the fiercest attack, however, and casualties amongst rear gunners are very high

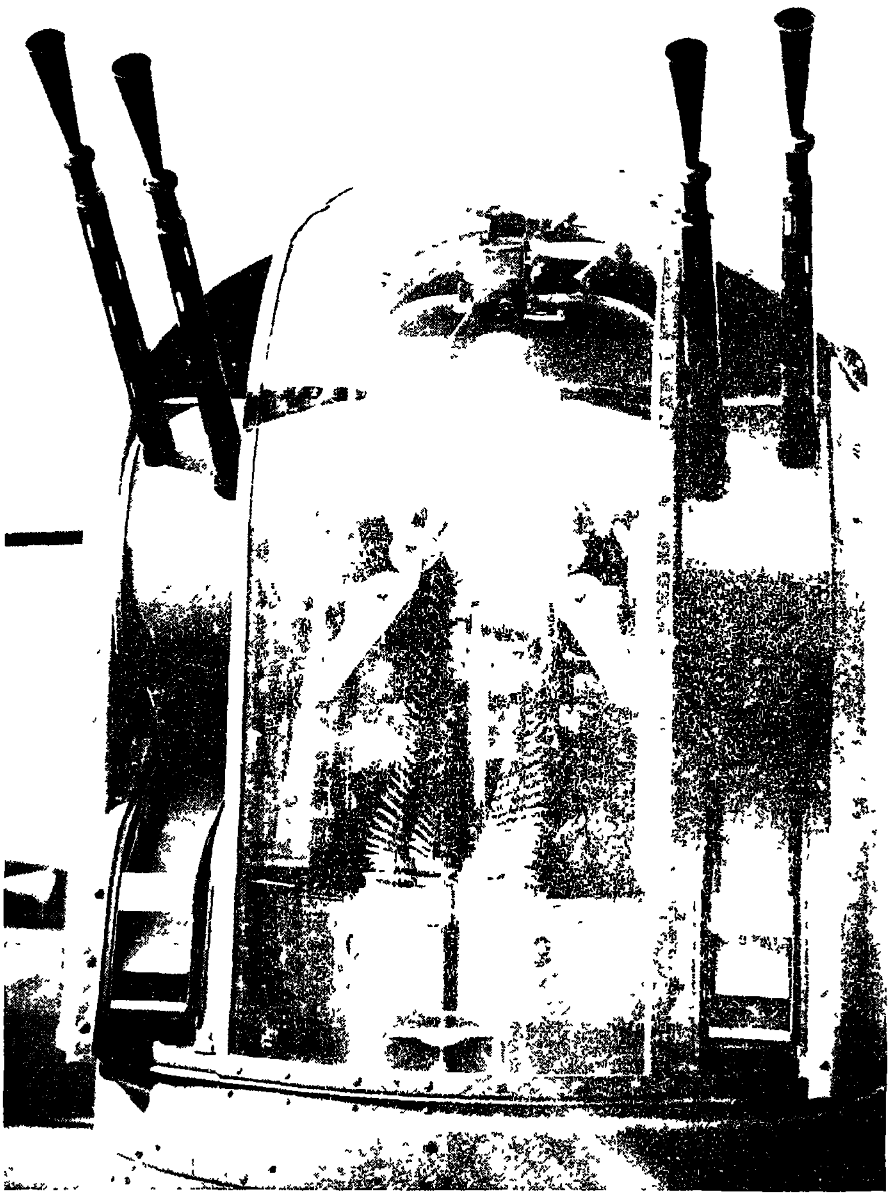
### WORK OF THE BOMBER

The work of bomber aircraft is more leisurely than that of the fighter—seconds are of less importance and speed is not so great—but it is every bit as exacting and may call for even more accurate flying While the pilot of a single-seater fighter will seldom be in the air for much more than two hours at a time, the pilot and crew of a bomber may be in the air for as long as ten hours, and for much of this time they will be exposed to the intense cold that is invariably associated with great heights.

As with the fighter, so there are two parts to the work of the bomber—reaching the objective and bombing it when it arrives To reach an objective hundreds of miles away during the darkness of night, with no radio to assist in position finding and with all lights blacked out on the ground, calls for very great skill in navigation and close co-operation between all members of the crew So important is the navigation work that it is a full-time job for one member of the crew (Fig 34)

The course to be followed is given to the navigator at the start of the flight It is unlikely to be a direct one from his aerodrome to his objective, and there may be changes of course on the way, depending on the amount of water to be crossed and on the number of strongly guarded points that may have to be circumnavigated. All available details about wind conditions and weather forecasts will also be given to the navigator

Weather forecasts are of the utmost



THE "STING IN THE TAIL"—A BRITISH BOMBER'S REAR TURRET

*Rear gun turrets are of vital importance to bombers in beating off attacks by enemy fighters. Here is a typical rear gun turret of a British bomber. Power operated, it enables the gunner easily to train his four machine guns on attacking fighters however fast they may be moving or however much his machine may twist or turn.*

**Fig. 34.** *The navigator of a bombing aircraft at work while on a flight*

importance on long-range flights, and it is for this reason that weather reports were put on the "secret list" immediately war began. Germany has as good and as numerous meteorological stations as have Britain and France, but most of the weather conditions over Western Europe can be foretold earliest in Great Britain. Weather changes generally come from the Atlantic and therefore reach Britain first. This point is of great importance in the conduct of aerial warfare

## IMPORTANCE OF WIND CHANGES

The chief difficulty with which the navigator has to deal is change of wind. Drift sights enable him to estimate the direction and strength of the wind in daylight, but on a dark night such estimation is far from easy. The importance of knowing the direction and strength of the wind is illustrated in Fig. 35. If a pilot attempts to fly from A to B by directing his aircraft direct to B, and keeping it on that bearing, and the wind is blowing from his port side (1), he will never arrive over his objective. Instead, the wind will drive him off his desired course (2) and he will arrive at a point somewhere near C According to the strength and direction of the wind, so he must direct his aircraft a number of degrees off his course and into the wind (3) He will then traverse a straight line from A to B.

On long flights the pilot may relinquish the controls and let the aircraft fly itself, once it has been set on its course. This is made possible by letting "George," the automatic pilot, take over the controls. "George" is a very wonderful and complicated piece of mechanism connected by pneumatic gear to the controls. The "brain" of this mechanism is a gyroscope and it keeps the aircraft flying level on its course. Since "George"

deals automatically with air bumps, it relieves the pilot from much strain and keeps him fresh for carrying out the critical part of his work when he reaches his objective. Some idea of the number of instruments and controls which the pilot of a modern aircraft has to watch and handle can be gained from the illustration of a cockpit on page 54

On the way over enemy territory the bomber may meet opposition in the form of enemy fighters or anti-aircraft fire. The only defence against anti-aircraft fire is for the pilot to zigzag and change height, but meantime he must maintain a course that is in general towards his objective, every effort being made, of course, to drive off any fighters that appear.

Fighters are the chief menace to bombers. Because of the superiority of the British fighter over the German bomber in aerial combat, Germany produced the special Messerschmitt "Me 110" already described. Such a fighter can accompany bombers on their raids and engage British fighters on their way up to attack.

There are obvious disadvantages in this course. Such fighters can only cover the necessary distances by flying comparatively slowly Once they open up their engines to their fullest power, their petrol supplies begin to disappear with incredible rapidity. Against the normal intercepter fighter operating near its own bases, they are severely handicapped.

Although Britain has available several new types of long-range fighters—the Boulton Paul "Defiant" already mentioned is typical—her policy has been to use these aircraft for engaging enemy bombers while still far distant from their

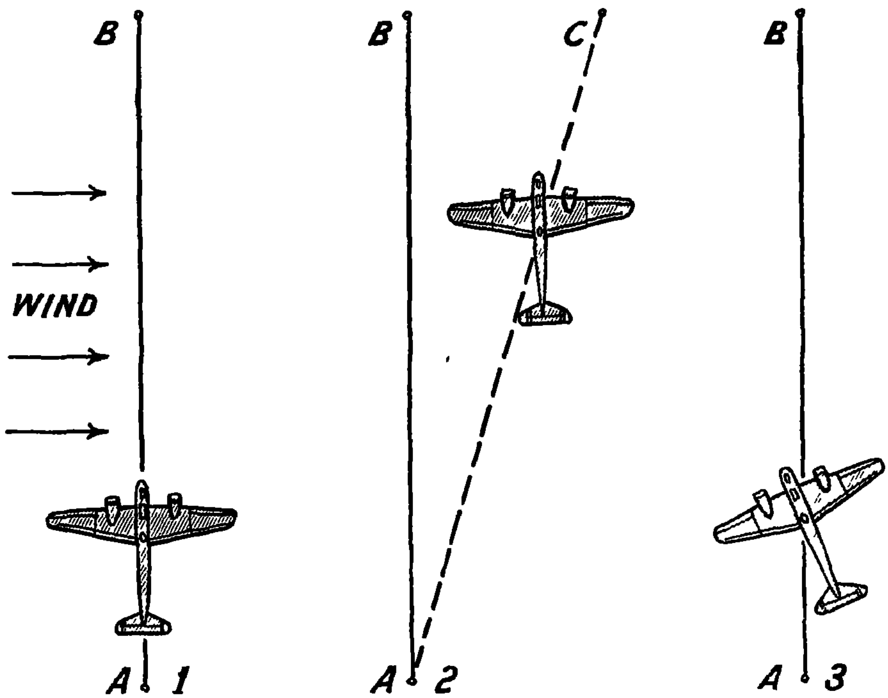
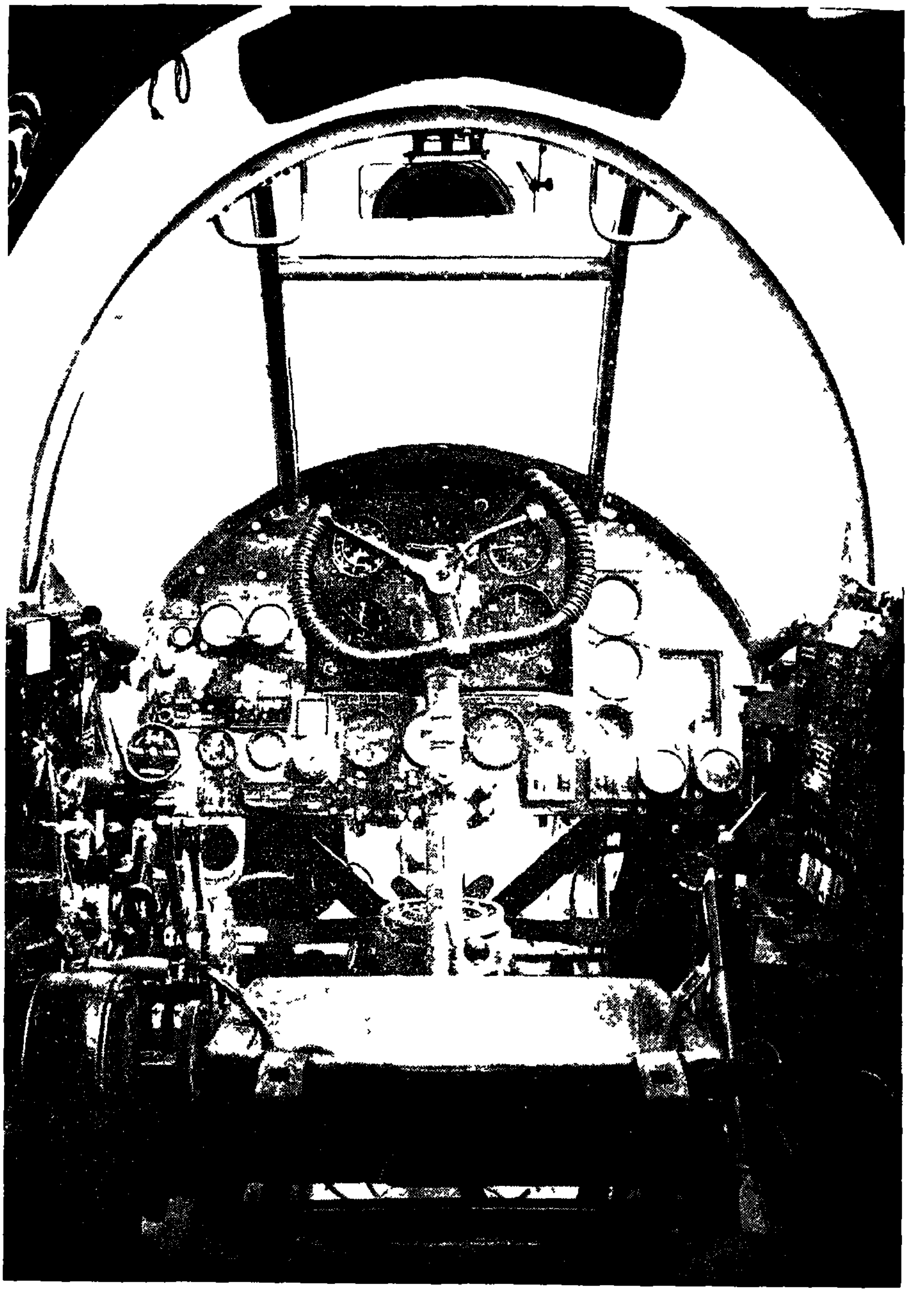



**Fig. 35.** *Effect of wind drift on a plane when flying between two points* (*see page 52*)



INSTRUMENTS AND CONTROLS OF A MODERN BOMBER

*The pilot of a modern aircraft has a complicated array of instruments to watch and check, as can be seen from this photograph of the cockpit of a "Hampden" twin-engined bomber*

objective. They are little used for convoying Britain's own bombers, which proves that they are well able to take care of themselves These bombers possess one great advantage over German bombers in their mechanically operated gun turrets

At the very high speeds reached by modern aircraft wind resistance is tremendous, and gunners are quite unable to swing their guns round rapidly by their own unaided strength Hence it is seldom that the dodging, twisting, fast-moving fighters ever come within their gun sights Mechanically operated gun turrets such as are fitted to the "Defiant" (Figs 6 and 7), enable the gunner to follow the movements of the fighter as rapidly as they occur Britain alone possesses the secret of their construction, and how effective these turrets are was proved time and again in the air battles that were fought by British bombers with German fighters over Nazi territory.

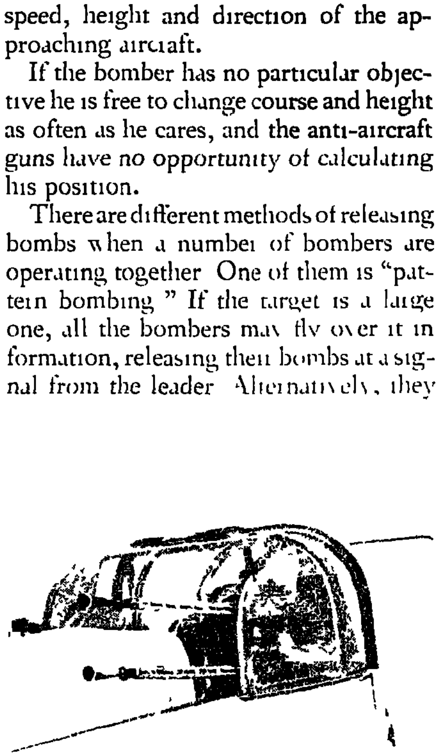
### ALTITUDE BOMBING

Having arrived over their objective the vital part of a bomber's work begins By day bombers always fly in formation Altitude bombing from heights of 8,000 feet or more is a highly technical business, calling for long and careful training and great skill on the part of the bomb sighter, and also for close co-operation from the rest of the bomber's crew

Before a bomb is dropped, intricate calculations have to be made to allow for such factors as height and speed of the aircraft and drift caused by wind (Further details of this part of the work are to be found in Chapter III ) It is essential, however, that while the observer is aiming his bombs the pilot must keep the machine steady on a dead level and perfectly straight course This is the most dangerous moment of the flight, for it gives the anti-aircraft batteries just that amount of time necessary to calculate speed, height and direction of the approaching aircraft.

If the bomber has no particular objective he is free to change course and height as often as he cares, and the anti-aircraft guns have no opportunity of calculating his position.

There are different methods of releasing bombs when a number of bombers are operating together One of them is "pattern bombing " If the target is a large one, all the bombers may fly over it in formation, releasing their bombs at a signal from the leader Alternatively, they



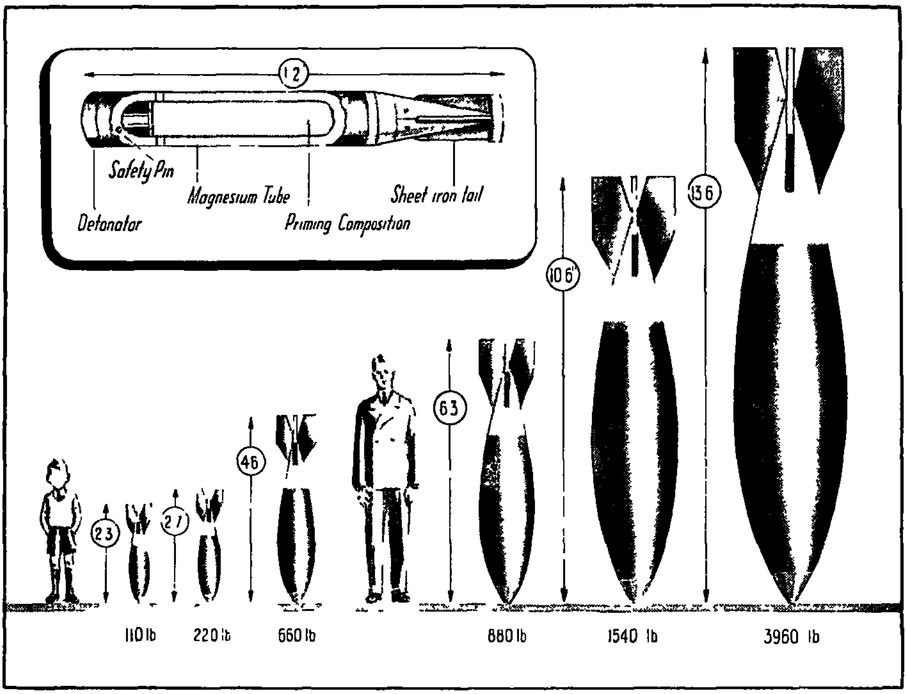
A FIGHTER'S TEETH

*The mechanically operated gun turret of the Boulton Paul "Defiant" There are two pairs of machine guns, one pair on either side*

take up a line-ahead formation each dropping bombs as they fly over the target

Low-altitude bombing is generally carried out by medium bombers. The concussion of a large bomb exploding is so great that if the aircraft releasing it is flying too low it may be thrown out of control The consequence is that pilots engaged in low-altitude bombing are given a minimum height according to the bombs they are using

The high-explosive aerial bomb generally used in modern warfare, for destroying military objectives, varies in size from




COMPARATIVE SIZES OF AERIAL BOMBS

**Fig. 36.** *The heaviest bombs are used only against military objectives of special importance (Inset) Section of typical incendiary bomb The priming composition (aluminium-iron oxide) is ignited by impact with the detonator, and burns at a very high temperature This melts and ignites the magnesium tube which continues to burn for from ten to twenty minutes*

50 lb. to 2,000 lb., although bombs up to 3,960 lb. have been made. Comparative types and sizes of some typical bombs are shown in Fig 36 Gas bombs may also be used in attempts to break the morale of civilian populations, but their destructiveness is very limited, and they have little except nuisance value against a population that keeps calm and a civil administration that keeps its head. Incendiary bombs are far more dangerous (*see* inset Fig. 36) Their most common size is the kilo bomb (so called from its weight of one kilogramme—about 2 lb. 3 oz.), but they may be as large as 50 lb A large bomber can carry some 2,000 or more kilo bombs, and as each bomb is capable of starting a serious fire the potential destructiveness of one bomber over a crowded urban area can be imagined. These bombs are usually carried in racks of ten or twenty inside the aircraft and are released in clutches

Any protuberance outside the smooth streamline shape of an aircraft causes considerable wind resistance, and therefore will reduce the speed. For this reason most aircraft today carry their bombs in compartments inside the wings or fuselage. The compartments have doors that are opened when the bomb-release mechanism is operated. Normally, the release mechanism is worked by electricity. The quicker a bomb descends, the less it will be affected by wind and thus the greater will be the accuracy of bombing. This is

why bombs dropped from aircraft are streamlined in shape. In addition to being streamlined, they have fins at the tail to ensure that they fall nose first. Most aerial bombs are exploded by a detonating cap in the nose.

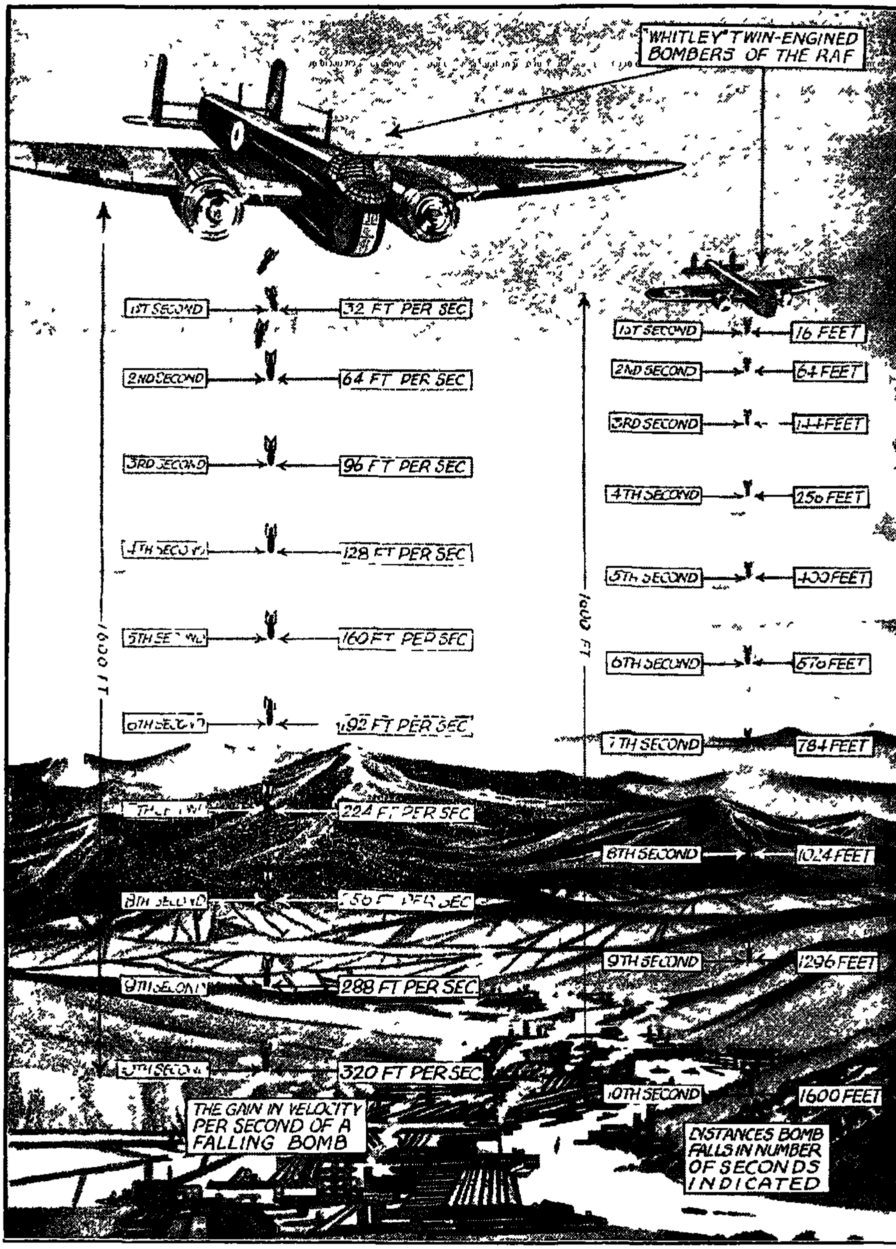
### HOW FAST DO BOMBS FALL?

Incidentally, the landing speed of bombs dropped from a great height is enormous A falling body moves at an ever-increasing speed, so that the greater the height from which the bomb is released, the greater the ultimate velocity of the bomb For example, a bomb falling from a height of 1,600 feet will fall 16 feet in one second, 64 feet in two seconds, 144 feet in three seconds and so on This is made clear in Fig 37, from which it will be seen also that the bomb's velocity at the end of the first second will be 32 feet per second, at the end of the third, 96 feet and so on. A bomb would reach the ground from a height of 1,600 feet in ten seconds, and by the time it reached the ground it would be travelling at a velocity of 320 feet per second Bombs dropped from a height of 12,000 feet will be travelling at over 700 m p h by the time they reach the ground!

As formation flying has been mentioned several times in the foregoing descriptions of air fighting, a few details about it may be useful Wartime formation flying is vastly different from the complicated formation drill seen at air displays in peace time, when the aircraft seem at times to have their wings almost touching Formation flying in wartime is resorted to simply to keep the machines together Most wartime formations are based on the V shape shown in Fig 38,

AUSTRALIANS LOAD THE "EGGS"

*Night bombs are fitted into special racks beneath the wings of machines used for low-altitude bombing Here two Australian airmen are seen fixing such bombs into their racks*




RATE OF FALL OF AERIAL BOMBS

**Fig. 37.** *Bombs, like all falling bodies, gain speed as they fall The left-hand column shows the actual speed in feet per second that a bomb has reached at any given second of its fall The right-hand column shows the number of feet it drops in any given number of seconds A bomb dropped from 12,000 feet would hit the ground at a speed of over 700 m p h*

with the leader in the front position, the two aircraft, one on either side of him used always to be at a slightly higher level (Fig. 39). The higher level of the rear machines enables them to increase their speed at any time by a slight dive They are thus able to keep their positions in the formation when going at full throttle In recent times, however, the increased performance of aircraft has enabled stepped-down formations to be used as well

Fig 40 shows how six aircraft would fly in formation in wartime The aircraft

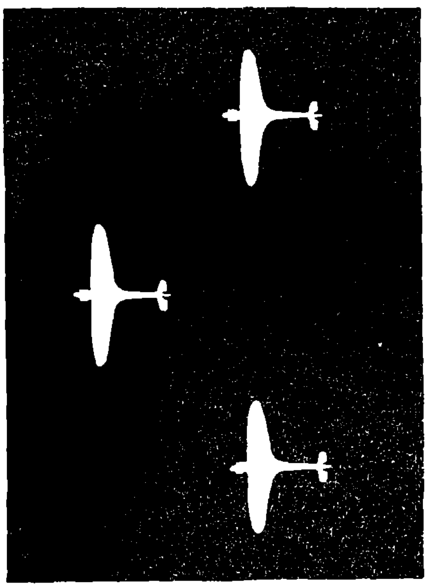


**Fig. 38.** *Diagram of V formation*

B and D would be higher than the leader A, and the aircraft C and E would be higher than B and D respectively The sixth aircraft F would be even higher than either C or E.

The Germans developed a new use for their bomber aircraft in the early months of the war As part of their unrestricted campaign against merchant shipping they began to scatter mines all round the coast of Great Britain, in the shipping lanes

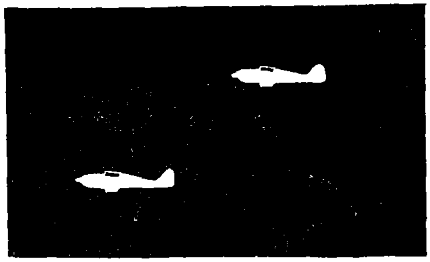


**Fig. 39** *V formation, side view*

and in her river estuaries such as the Thames and the Humber At first these mines were laid by submarines but the anti-submarine work of the Royal Navy made the hazards too great So a number of special seaplanes were converted into minelayers Their base was in the islands off the north-west German coast, notably Borkum and Sylt and from there they

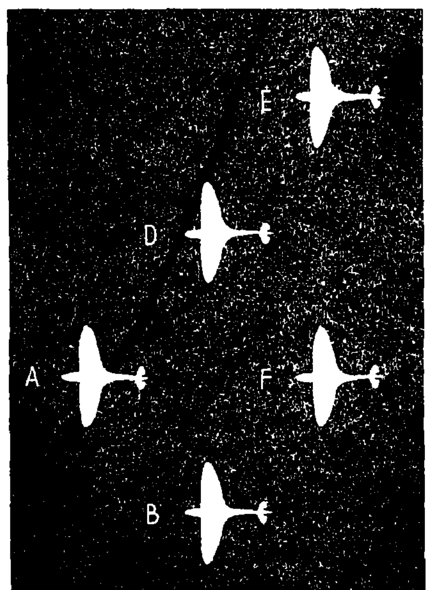
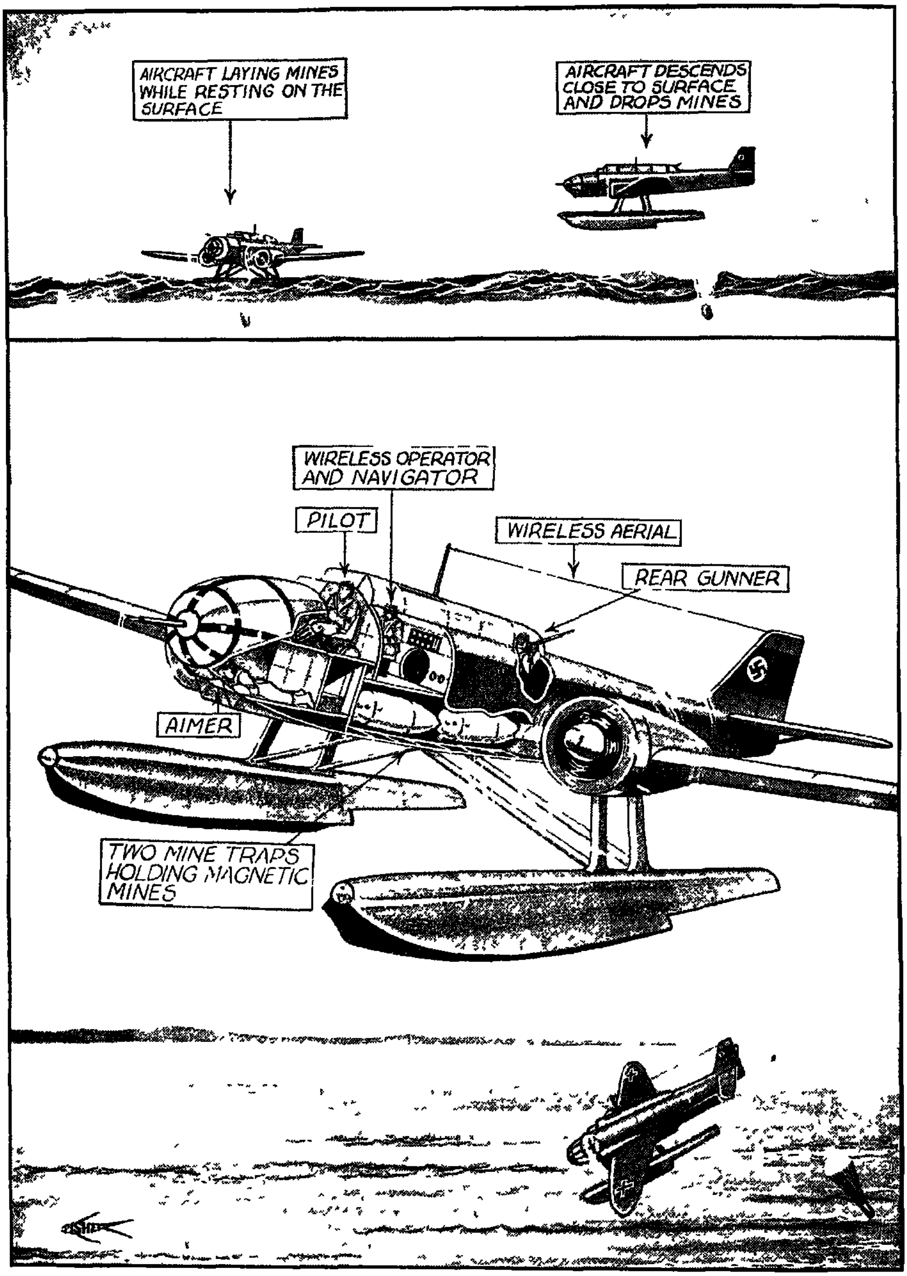



**Fig. 40** *Wartime formation of six aircraft*




HOW GERMAN MINE-LAYING SEAPLANES WORK

**Fig. 41.** (*Top left*) *Aircraft laying mines directly into the sea* (*Top right*) *Aircraft dropping mines into the water* (*Below*) *Details of German seaplane fitted for laying magnetic mines which may be dropped by parachute* (*below right*) (*See also Chapter VII*)

could cross quickly to the British coast, lay their mines and return in a matter of a few hours.

These seaplanes (Fig. 41) laid their mines by coming to rest on the surface of the sea, by dropping them from very low heights, or possibly by dropping them from greater heights on parachutes.

### THE "SECURITY" PATROLS

For a time the activity of these seaplanes proved serious, but the R A F. rose to the occasion. The Bomber Command began a regular patrol of the German seaplane bases, a feat undreamt of in its audacity Day after day, night after night, through the bitter winter months these "security" patrols continued. Always the enemy aircraft were subject to attack by German fighters and from batteries of anti-aircraft guns. But the patrols never ceased and the result was that the German seaplanes remained at home.

The bald description given previously does not perhaps convey to the reader the real story of ceaseless effort, strain and high courage that lies behind the work of pilot and crew of a bomber on raiding expeditions Let us, therefore, accompany a bombing aircraft on a raid to a German naval base Previous to the flight, the pilot is called with the other pilots of the bombing formation to the Operations Room of the aerodrome He is told of the nature of the raid in an informal address by his commanding officer The course is pointed out on a map and remarks are made such as. "Here you may expect heavy anti-aircraft action, so you will be flying high, about 27,000 feet . . at this point you will alter course and begin to descend, so that at 5,000 feet you should get a glimpse of your objective in the distance by the time you reach this point . . . thereafter you will proceed as conditions dictate Has any one any questions?"

Generally, everything will have been worked out in such detail that the procedure is perfectly clear, and with a word of good luck the commander dismisses the crews. Before our pilot goes to his aircraft, the leader of the flight will give him maps showing the course.

Shortly before the time to take the air, the pilot assembles with other members of the crew The pilot probably has put on several pullovers to keep him warm. On goes the fur-lined flying suit, the sheepskin boots, gloves, and flying helmet Finally, the pilot straps on his parachute and climbs into the bomber, making his way forward to the controls. The engines are running, his safety harness is adjusted, observer, radio operator and rear gunner are aboard The signal comes to take off As the pilot waves his hand, the ground personnel withdraw, the engines are opened up and the aircraft taxies into position for a lone take-off With a roar the engines lift the fully loaded aircraft into the air

At 2,000 feet the other aircraft of the formation are joined, course is set and all head for the coast. A quick glance of his skilled eye tells the pilot that the engines are functioning properly, and that all controls are set correctly He slides shut the window at his side, for it will soon be cold as the aircraft gains height. Oxygen masks will be needed at their cruising height, and so the pilot tests out his supply A message is given by the observer to the pilot. It says, "Course O K."

### PROGRESS OF A BOMBING RAID

There is an hour's flight before a change of course will be needed, so the pilot puts in "George," the automatic control that will fly the aircraft on its course, and relaxes. He will need all his reserve nerve power and energy later. But his attention never wanders After a while the coast is cleared, a convoy is seen far below, and a heliograph sends a signal. It is taken down by the wireless operator who has come forward because his radio

cannot be used now for fear of giving away the approaching raid to the enemy. "Best of luck" says the message from the destroyer, shepherding its merchant vessels on the choppy sea below The pilot smiles, and flashes a reply "Many thanks."

Shortly afterwards the sea is obliterated as heavy clouds loom up. The aircraft begins to buck and the pilot decides to take over control again, flying blind by means of his instruments. Frost gathers on the windows of the cabin, the controls get heavy as ice forms on the wings But the pilot calmly flies on. The crew sit back and wait quietly Presently the clouds clear and the formation closes together again

Surely, thinks the pilot, it is time to alter course Almost at the same moment comes another note from the observer, "Alter course to so-and-so " The pilot nods and adjusts his compass. The observer checks the setting and a slight movement of the controls brings the bomber on to its new course Now it is time to come lower The nose tilts slightly The pilot checks up on his crew Gunners at their stations, bomb aimer in position below him Everything O K The flight has so far been uneventful The anticipated anti-aircraft fire has not materialized, but they are now nearing the enemy coast There is an air of tenseness, but the friendly company of the other aircraft makes itself felt.

### "FIGHTERS BELOW"

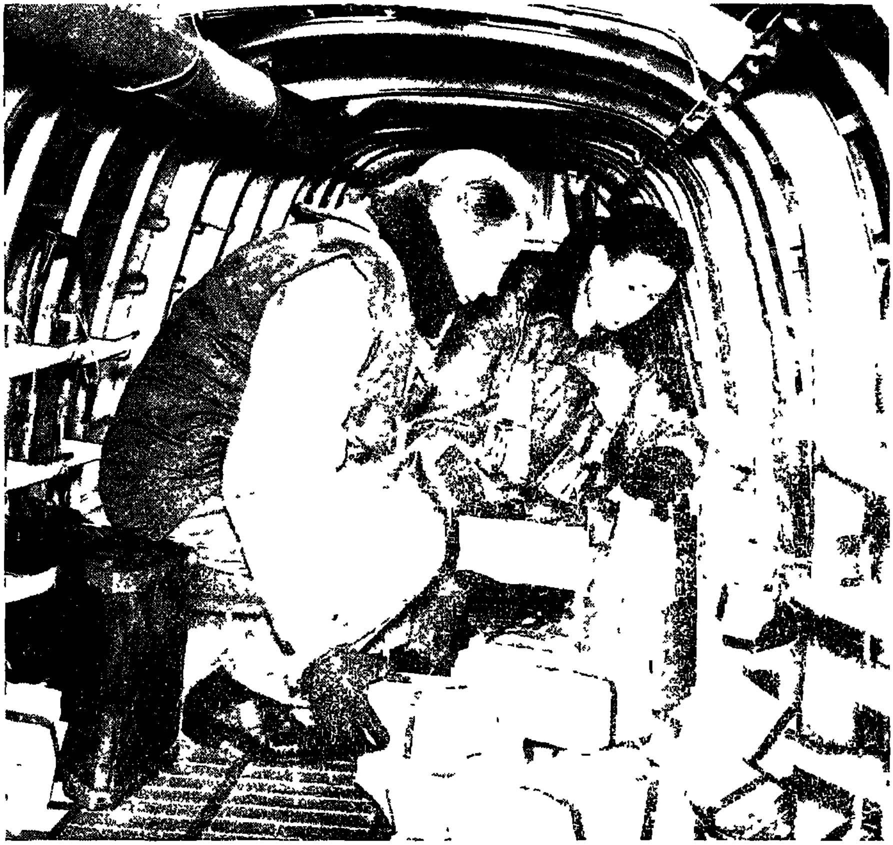
At 5,000 feet the pilot strains his eyes for a sight of the coast There it is, and the shape of the naval base can just be discerned He glances at the leading aircraft, and gets a signal to break formation and go in singly to bomb "I wonder why?" the pilot thinks "Perhaps enemy fighters have been spotted " At that moment the gunner in the tail lets off a few rounds from his gun. The bomber is being attacked But the pilot has no time to think about that, his bomb aimer is signalling to him to turn right a little Now the course is dead right and the pilot concentrates on straight flying. They are now nearly over the base Up goes the bomb aimer's hand. He has released his bombs. Even as these swoop to the earth, machine gun bullets snap through the cabin and the bomb aimer subsides quietly on the floor

### END OF THE RAID

But the raid is over and a steep turn takes the huge machine round, its guns blazing away at fighters swarming around it. Twisting and turning the pilot heads his craft for home, ignoring the stray bullets that pass through the cabin. On his right a fighter goes down in flames "Good for Harry!" thinks the pilot Harry is his rear gunner

A friendly cloud looms up and the pilot heads into it Almost as suddenly as the fighters swooped on his machine they are gone As the world is obliterated he feels as safe as though he had shut a steel door behind him, and his thoughts turn to his bomb aimer. But a member of the crew is already dressing his leg. He is not too badly hurt. Now he is sitting up and smiling wanly A feeling of reality once again comes to the pilot. Frozen, but warmed from within with a sense of elation, he mentally tries to urge his machine on, to get back to the peace and security of his aerodrome and the snug comforts of the mess

Once again the wake of ships is seen below Once again the coast is crossed, and presently the aircraft has rumbled to a landing at the home aerodrome The wounded bomb aimer is rushed to the hospital, and stretching cramped limbs the pilot lights a cigarette with numbed fingers and makes his way to the Operations Room to report. A little later he enters the mess-room. Inquiring eyes accost his across the room. But, "What's



HOW THOUSANDS OF LEAFLETS ARE RELEASED OVER GERMANY

*Time and again British bombers penetrated far into Germany, Austria and Poland on their famous leaflet-dropping expeditions Great courage, perseverance and cool nerves were needed by the pilots and crews who made these flights In this picture two members of a bomber's crew are seen with bundles of leaflets ready to drop down the special chute*

for dinner?" is his only remark as he seats himself in the most comfortable chair and picks up a magazine.

Bombers are not always used for bombing. They are quite as frequently employed on photography or reconnaissance flights, or even for the dropping of leaflets on enemy territory From the first day of the war the R.A F carried out a series of astonishing flights over Germany reaching not only Berlin and the Baltic ports, but also Prague and Vienna. Reconnaissance flights and their object are dealt with more fully in Chapter IV. Here it is necessary only to record appreciation of the high valour, skill, enterprise and perseverance that mark them. They prove also the reliability of British machines and the excellence of the organization behind them In the next chapter we shall learn something of the organization and administration of this the youngest of the Empire's fighting services, the Royal Air Force.


[Medals by courtesy of Messrs Spink & Sons London

DECORATIONS OF THE ROYAL AIR FORCE

*1, Distinguished Flying Cross, obverse 2, Air Force Cross, obverse 3, Distinguished Flying Medal, reverse 4, obverse 5, Air Force Medal, reverse, 6, obverse All the above decorations for acts of valour and gallantry were instituted by Royal Warrant on June 3, 1918 The Distinguished Flying Cross is awarded to officers of the R A F for acts of exceptional valour, courage, or devotion to duty while flying in active operations against the enemy The colour of the ribbon is blue stripes on a white background The Air Force Cross is awarded for the same acts while flying, though not in active operations against the enemy This has a ribbon of red stripes on a white background The Distinguished Flying Medal and the Air Force Medal are awarded to non-commissioned officers for the same acts that earn for officers the D F C and the A F.C They also carry similar ribbons, though with narrower stripes Both the A F C and the A F M can be won by civilians The Victoria Cross, which can be won by members of all three Services, is illustrated in the third section of this book, dealing with the Army*

# CHAPTER II

# ADMINISTRATION AND ORGANIZATION OF THE R.A.F.

THE Royal Air Force, compared with the Navy and the Army, is a very young Service—actually it celebrated its twenty-first birthday on April 1, 1939 Because of its youth there are few dogmas existent about its organization and administration Flexibility, the chief feature of its control, is a vital feature to the Air Force, for there are many theories about war in the air that have yet to be put to the test in actual practice

The R.A.F is essentially a democratic Service Developed during the hey-day of democracy, following the war of 1914-18, it has always possessed a freedom from conventions that has only begun to show itself in the Navy and Army during recent years.

This fact, while not reflecting in any way on the two senior Services, emphasizes the youthfulness and amazingly rapid development of the Royal Air Force. Youthfulness is an apt word, because air fighting essentially makes big demands on the qualities of spirit and endurance that are to be found essentially in young men.

During the greater part of the war of 1914-18 the aeroplane was regarded as an implement either of the Navy or of the Army The Air Force then consisted of two distinct parts, the Royal Naval Air Service and the Royal Flying Corps Each branch was independent of the other and was itself under the control of one or the other of the two existing fighting Services Towards the end of 1917, however, air fighting had assumed such importance and grown to such proportions that the need for an independent air force as a primary instrument of war was realized. Strategical air operations passed beyond the scope of limited naval

*A fine view of a squadron of "Spitfires" flying in flights of three*

or military direction. Thus it came about that in 1918 the Royal Air Force was formed. Co-operation with the Army and Navy was still important—it remained as close as co-operation between the Navy and Army themselves—and certain units were still employed essentially on naval or military work

Today, the position is much the same The Royal Air Force is maintained as a fighting service on its own, its work being co-ordinated with that of the Navy and Army. But the Navy and Army still have need of aircraft for their own individual operations. To meet this requirement the Fleet Air Arm (dealt with in more detail in Chapter X) was brought into being The Fleet Air Arm is a completely separate body entirely under the administration of the Admiralty

The aircraft used by the Army form a separate section of the R.A F., and are known as Army Co-operation squadrons. They carry out special duties, but are not a part of the Army itself. (*See* Chapter IV.)

Even before the outbreak of war in September, 1939, it had been suggested that the Army, like the Navy, should have its own fliers. Early in 1940 the War Cabinet, having recognized that some modification in the existing organization had become necessary, decided to create a separate command for the R.A. in France. This step afforded better c operation with, and greater support fo the Army This R A F. command, which included all the units of the R A.F. in France, was named the British Ai Forces in France Command. It wa placed under the command of an Ai Officer Commanding-in-Chief, responsible—in consultation with the Army Commanders-in-Chief — for ensuring the most effective support to the British Expeditionary Force and the French armies on the Western Front. This officer was also responsible for co-ordinating the operations of the R A.F with those of the French Air Force.

### THE R A F. IN FRANCE

The arrangement involved no change in principle in the relationship between the Army and the R A F , being based or the analogy of the existing relationsh between the Royal Navy and the Coas Command of the R A F

When the command was set up ther were two divisions of the R A F i France, one consisting of the Army Co operation squadrons and the other of th bombing, fighting, and other units. T effect the change the Bomber Commanc was divided into two parts, the first operating in France and the second, anc

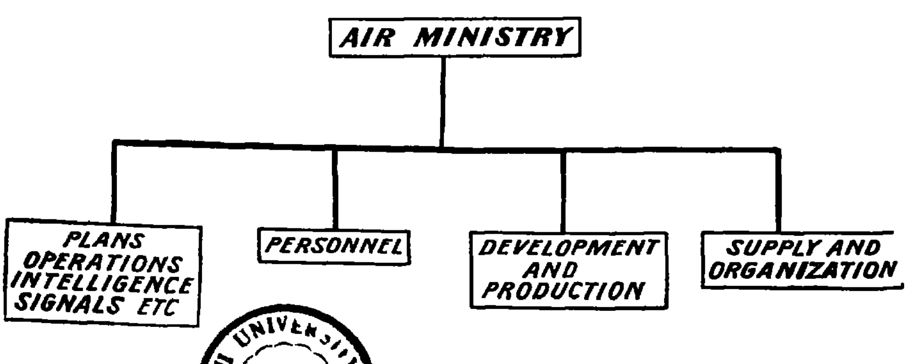



**Fig. 1.** *Diagram showing in simplified form the four chief departments of the Air Ministry.*

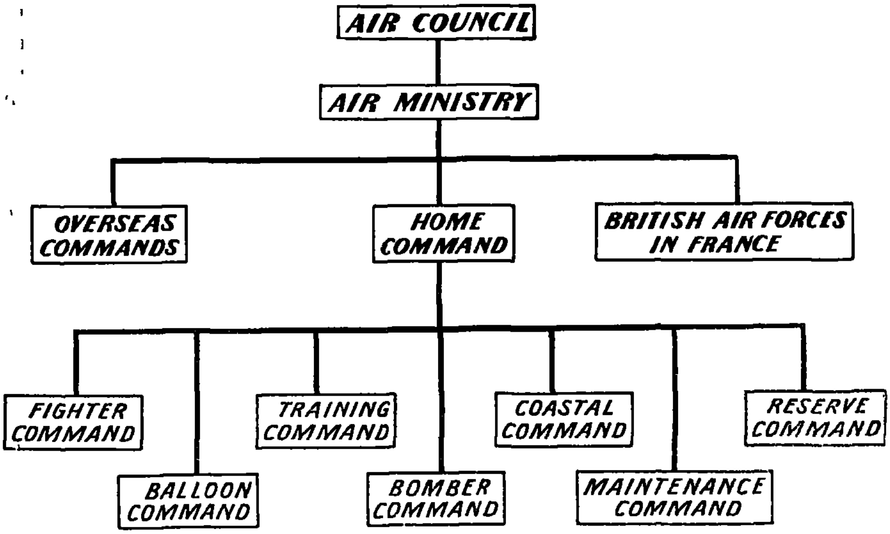



Fig 2 *How the work of the R A F is divided into commands*

larger part, operating from a number of different bases in Britain

The new command was made directly responsible to the Air Ministry Thus all R.A F units in Britain and France—including those for defence as well as those to be employed in counter-attack—were kept under the control of headquarters in Great Britain

The following outline of R A F administration will give a picture of how the vast organization is controlled

The Air Ministry is the headquarters of the whole R A.F., but it is not the supreme commanding body The highest control of the R A F is invested in the Air Council, and this body receives its instructions direct from the Government

The Air Council is made up of active high officers of the R.A F , permanent civil servants, politicians, and civilian technical advisers The president is the Secretary of State for Air The R A F officers are known as Air Members, and the senior Air Member is the Chief of the Air Staff He acts as the principal adviser to the Secretary of State for Air

The Air Ministry is divided into a number of large departments, the heads of which are the R A.F officers who are the Air Members of the Air Council Thus, the Air Council is assured of first-hand information on any detail of R A F. organization Also, during peace time at least, the Air Members do not hold their positions permanently Air Members—or departmental chiefs—are chosen to serve for a period from officers carrying out active duties in the R A F and who have passed through the Staff College The Staff College, maintained at Andover, Hants, is a training centre where specially selected officers pass through a course that gives them an insight into the administration details of the Service

Four of the departments at the Air Ministry (shown diagrammatically in Fig 1) are those dealing with (1) Plans, Operations, Intelligence, Signals, etc , (2) Personnel, (3) Development and Production, and (4) Supply and Organization The plans and operations department is principally for co-ordinating the work actually by the Air Force, and for putting

into operation the decisions made by the Air Council. The department dealing with personnel is concerned with the training of pilots and other members of the R A F., with their recruitment and promotion, and with their welfare. The design of new aircraft and experimental work is the concern of the department dealing with development and production. This department is in close contact with engineers in the aircraft production industry. The supply of equipment, the building of new aerodromes and similar considerations are the chief concern of the supply and organization department.

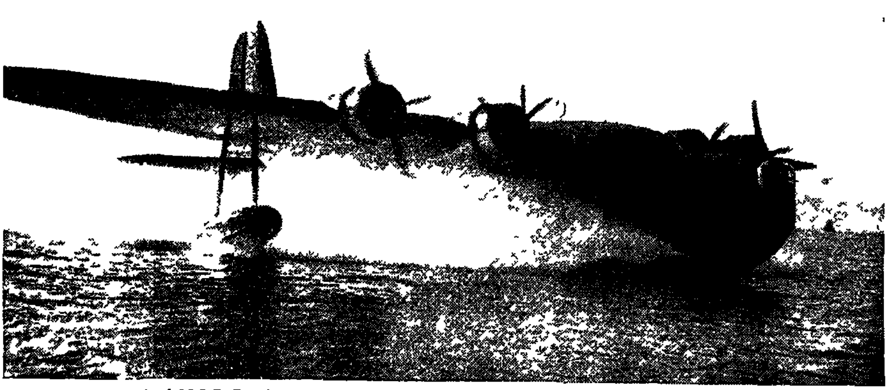
The Chief of Air Staff is the focal point where the directors—or heads—of the departments, and the officers in charge of the various commands, meet

The work of the R.A F. is conveniently divided up into a number of "commands." There are Home Commands and Overseas Commands The Home Commands are each concerned with a particular type of work, while the Overseas Commands are divided according to the area in which they operate (Fig. 2).

Of the Home Commands concerned with active service operations there are three: the Fighter Command, the Bomber Command, and the Coastal Command (Other Home Commands are dealt with later ) The work of the first two speaks for itself and has been already dealt with in Chapter I. The work of the Coastal Command is less obvious.

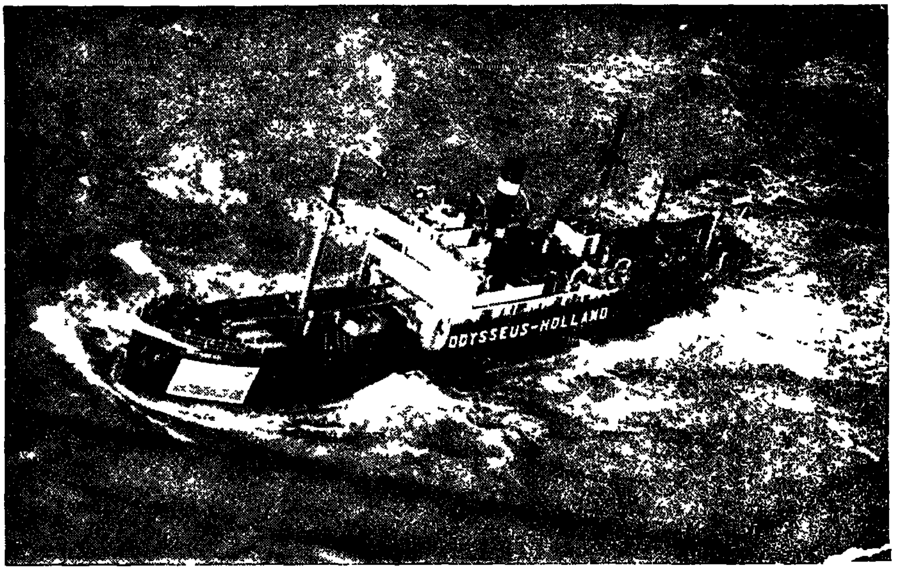
### THE COASTAL COMMAND

In the early months of the war, however, the Coastal Command figured more prominently in the news than any other branch of the R.A.F. This was because its activities were of such a nature as to bring it into more frequent contact with the enemy. Those early months saw no serious bombing attacks by any one of the belligerent powers, except on seaplane and naval bases and ships at sea. In this work the Coastal Command played the principal role Its work could be defined as the patrol of Britain's coast, with reconnaissance of enemy shore bases and, in close co-operation with the Navy,



A SHORT 'SUNDERLAND' FLYING BOAT TAKES OFF

**Fig. 3.** *These four-engined giants of the air weigh over twenty-five tons and cost approximately £85,000 each to build. Known affectionately as "Monty" to all and sundry, they carry a crew of ten and have a range of over 2,000 miles*




NEUTRAL MERCHANTMAN SEEN FROM THE AIR

**Fig. 4.** *A patrol plane flies over a neutral merchantman Every neutral ship met on patrol is carefully checked by the aircraft of the Coastal Command*

with the guarding of the seas and the protection of merchant shipping.

Its aircraft are of all types, landplanes and seaplanes. Among the latter are to be numbered the large flying boats, particularly the four-engined Short "Sunderlands." These flying boats are not, as is sometimes assumed, part of the Fleet Air Arm. Each of these £85,000 flying boats weighs some twenty-five tons and carries a crew of ten. It may use as much petrol in one day's routine work as an average weekend motorist might consume in six months. From Gibraltar to Iceland, from the German and Scandinavian coasts to the wild wind-swept spaces hundreds of miles out in the Atlantic, the Coastal Command maintained ceaseless watch.

Its work is never humdrum. There is romance in every one of its flights. Each is a story of high adventure and matchless courage, of brave spirit and indomitable purpose. Day after day in fair weather or foul these knights of the sky skim over the oceans, spying out foes, protecting friends. Even in the first five months of the war aircraft of the Coastal Command had flown over 5,000,000 miles on patrol or reconnaissance work Any one of their twenty-five ton flying boats might cover up to 1,800 miles a day, a journey equivalent to the Atlantic crossing between Ireland and Newfoundland

### SEA RESCUES BY PLANE

Their work is to be interpreted partly as an errand of mercy More than once, these great flying boats came to rest on the waters beside some crazy raft carrying the exhausted survivors of some U-boat outrage and spirited them away to safety. More than once these same boats guided some near vessel to other survivors tossing helpless and hopeless in open boats.

Let us accompany one of these aircraft on a typical day's work. In the cold light of dawn, the crew of one of these monster flying boats climbs aboard In a few

SCANNING THE WATERS
**Fig. 5.** *Pilot examining ships through his binoculars Incidentally, the crew of these flying boats are allowed to smoke on duty*

moments "Monty" is gliding over the sea in a smother of foam (Fig 3) Why these boats are called "Monty" no one knows—but "Monty" they are to all and sundry As the light grows stronger over the English Channel, there below is a simple-seeming merchantman, by her signs a neutral (Fig 4) The pilot circles.

### HOW SHIPS ARE CHECKED

The ship is photographed at all angles and her appearance is hastily checked with a copy of *Merchant Ships*. She may, after all, be a German vessel or even a raider in disguise If she is and the pilot is doubtful, it will be discovered by the experts on shore when the photographs are developed Immediately news of her will be flashed to patrolling destroyers who will quickly round her up

After half an hour's flying the pilot (Fig 5) spots through his glasses a small group of ships far below "Monty" drops seaward, flashing the day's code message to the attendant destroyer. For this purpose a special hand lamp, the Aldis signal lamp, is used The ships are some lame ducks of a convoy that the pilot has been asked to round up He circles and is off again in search of the main convoy Thirty miles away he picks it up Again the day's code is flashed to the destroyers (Fig 6) The pilot has too healthy a respect for the marksmanship of their anti-aircraft guns to take any

A CONVOY SEEN FROM PATROLLING BRITISH AIRCRAFT
*Aircraft of the Coastal Command assist the Navy in protecting convoys Flying high above the ocean they round up stragglers and keep a constant watch for U-boats*

MAKING THE CODE SIGN OF THE DAY

Fig. 6. *The pilot of a Coastal Command flying boat signalling, by means of the Aldis lamp, the code sign of the day to destroyers guarding a convoy of merchant ships.*

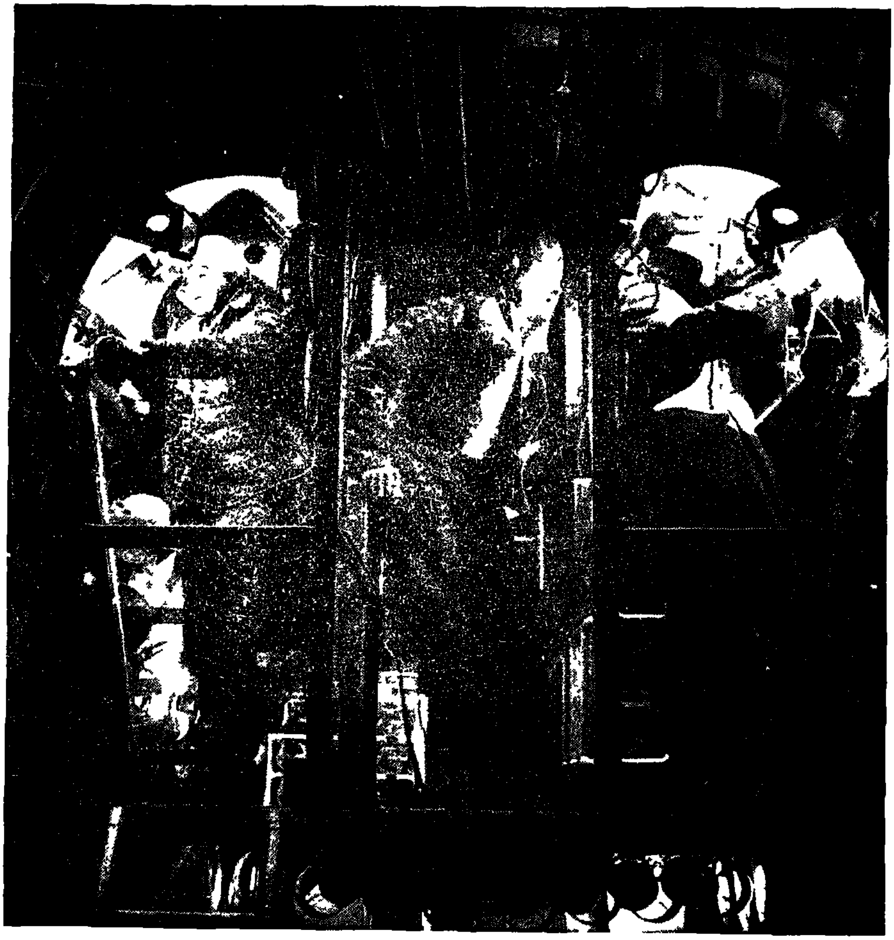
chances. He follows the code message with word of the lost ships.

Back again the giant flying boat turns and gives directions to the stragglers.

### GUARDING THE CONVOYS

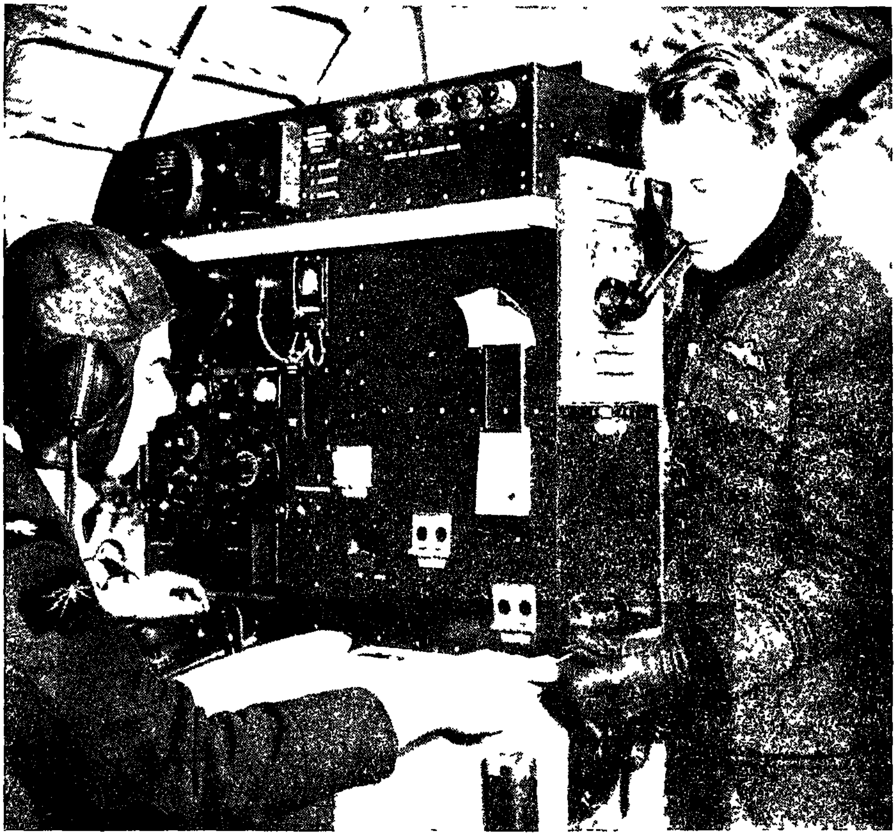
Then starts the routine work of the day In vast figures-of-eight the pilot covers the sea for miles around the convoy. He flies low or high by turns and every free member of the crew scans the waters below (Fig. 7). Suddenly one shouts. He has spotted a periscope. A submarine is lurking in the convoy's path.

There is a mighty roar as the four engines are opened to full throttle. Down dives the aircraft to where, her shape clear below the water, the U-boat glides silently. The crew of the flying boat are at their stations Pilot and bomb aimer calculate distances. a button is pressed and, as the great flying boat zooms



ON THE LOOK OUT FOR U-BOATS

Fig. 7. *Members of the crew of a Short "Sunderland" flying boat on patrol scan the sea for submarines An idea of the size of these flying boats can be gained from this picture*



*The pilot of a flying boat collects a code message from "Sparks," the wireless operator*

upward, a clutch of 250-lb. bombs speed downwards. Below in the grey sea is a roar of explosions and fountains of foam.

Casually, "Monty" continues her flight, winging back towards the convoy, and once again the Coastal Command has taken its toll of the undersea raiders. The machines of this command had sighted over one hundred U-boats, had attacked sixty-eight and had destroyed a minimum of six before four months of war had passed. Wherever there was the slightest element of doubt no claim of destruction was ever made.

Sweeping on past the convoy again, "Monty" crosses another hundred miles of sea. From there, radio messages of the convoy's progress and weather conditions are flashed back to the base. Even if they are picked up and decoded by the enemy, they will tell nothing of the convoy's whereabouts.

The weather is getting bad. Out in the Atlantic, rain driven by a fierce gale lashes the windows of the aircraft. The pilot goes on calmly smoking his pipe. "Sparks," the wireless operator, appears with a message. Because of the weather the flying boat is recalled. Through a rift in the clouds the convoy is sighted once more. Down swoops the plane to circle the ships wallowing in the heavy sea. "Cheerio" is flashed to the destroyers and off the flying boat swings once again.

DINNER TIME IN THE AIR

*So vast are the Short "Sunderland" flying boats that meals can be served during a flight Here a merry party sits down in the roomy cabin One man is always in touch with the pilot*

Through the blinding rain and the gathering dusk it spins onwards at a steady 100 m p h or more The weather clears. Then with a splutter of engines, it comes gracefully to rest on the water The crew clamber out "Short trip, chaps!" says the navigator, "only 1,200 miles today."

Tomorrow they will be off again and one more convoy of ships carrying merchandise and sinews of war will be docked safely in a British harbour It is significant to record that the percentage of ships under the care of the Coastal Command lost by enemy action is negligible.

So much for the work of the Home Commands The Overseas Commands work in various parts of the British Empire and are to be found in the Mediterranean, in India, and in the Far East, as well as in other parts of the world In wartime, as much as in peace time, their work is to keep open the imperial shipping routes, to protect ships, and to maintain aerial routes in operation It must be remembered that even when a war is confined to Europe, it is of vital importance that Empire links shall be maintained, and it is impossible to be sure that a European war may not spread In this connexion the trunk routes used by Imperial Airways in peace time are of great assistance in the moving of aerial support from one part of the Empire's territories to another

Also of great importance are the air forces of the Dominions, units of which began to arrive in England to join the R.A.F even before the end of 1939. Although the operations of these units may be controlled by the Royal Air

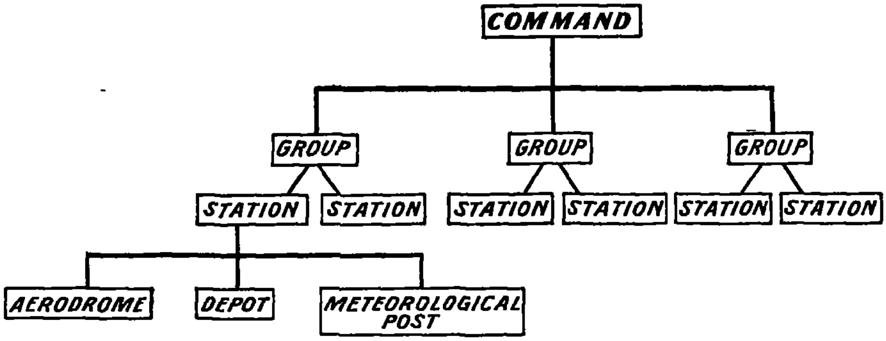



**Fig. 8.** *This diagram illustrates the structural organization of the command It is not to be assumed that there are always three groups in every command or two stations in each group The number of dependent organizations varies*

Force, the units nevertheless remain part of the Dominion air force from which they come (The Empire air training scheme in which the Dominions share, is dealt with in Chapter III )

In addition to the three Home Commands already mentioned, there are Training, Maintenance, Balloon, and Reserve Commands at home The work of the Training Command is self explanatory The Balloon Command is concerned with the captive barrage balloons that are flown over certain strategic points For purposes of administration, even after the outbreak of war, the Reserve and Auxiliary Air Force personnel were not entirely incorporated as regular members of the R A F , although certain changes in the

HOME AFTER THE DAY'S PATROL

*"Monty" comes down gracefully to rest after the day's patrol of 1,200 miles or more. In fair weather or foul Coastal Command aircraft daily patrol the seas around Britain.*

work of the Reserve Command inevitably occurred.

The Maintenance Command is one of the most recent. Its work is to supply the various units of the R A.F. with the aircraft, armaments, instruments and other equipment that they need, and to keep records of the stocks of equipment and spares. It was partly formed so that there would exist an organization to handle the great increase of equipment that would be required on the outbreak of war

The Balloon Command is one concerned primarily with home defence, although similar barrages may be used on a fighting front or behind it to protect important objectives. (Some more details about the balloon barrage will be found in Chapter V )

### THE "COMMAND"

The "command" (Fig 8), is the largest "self-contained" unit of the R.A.F It is itself divided, however, into smaller sections known as "groups." Each group in its turn is composed of a number of "stations," and these may be termed the individual units of the R.A F. A station may consist of a single aerodrome, it may be an aerodrome plus a meteorological observation post and a depot, or a number of aerodromes

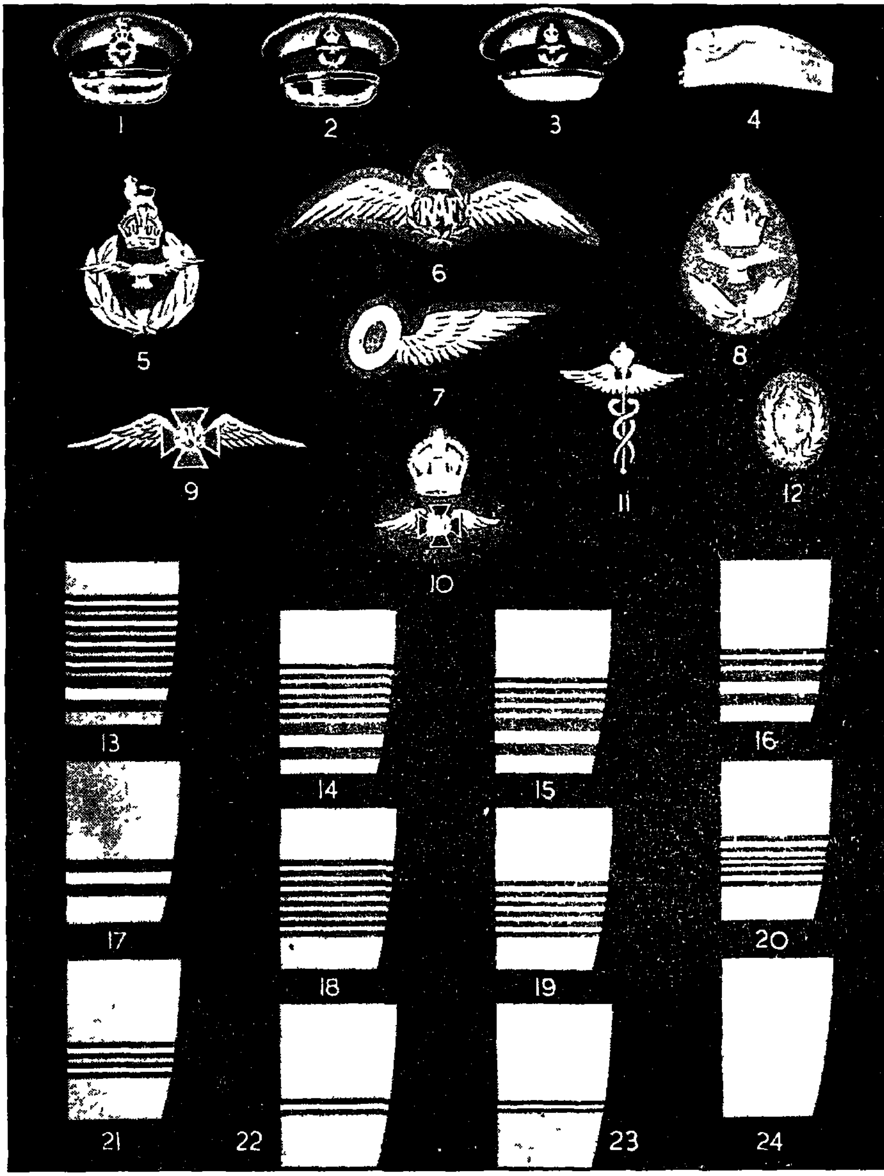
Each station has several squadrons of aircraft attached to it The basic fighting force of a squadron is nine aircraft, though there is a difference between peace time and wartime establishment, and this is divided into three flights of three aircraft each. Three such flights can be seen in the illustration on page 65. This does not mean that each squadron has only nine aircraft available, for the actual number in a squadron may be very high when all the reserve aircraft are taken into account

Let us now turn to the personnel of this vast organization, the men who do the work First a word on ranking. It will be realized that two of the officer ranks in the R.A F. are obtained from the terms "squadron" and "flight" of aircraft But it must not be assumed that a flight of aircraft is always led by a flight lieutenant, or a squadron by a squadron leader Nor must it be assumed that flight lieutenants are always pilots Men with these ranks might be doctors or accountants Ranks descriptive of flying are naturally used throughout all branches of the R A.F. The ranks and badges of the R.A F are shown in Figs 9 and 10

Not all flight lieutenants or squadron leaders are pilots, therefore, but every pilot—whether he be a commissioned officer or an N.C O , and whether he is still actively engaged in flying aircraft or did so only in the past—wears distinguishing wings above his left-hand breast pocket (*see* No. 6, Fig. 9). There are many non-commissioned pilots in the R.A F and their normal rank is that of sergeant Practically every airman in the R.A F who joins young enough and is fit enough, has an opportunity of working his way up to a position where he may be selected for training as a pilot. "Airmen" is the term used to indicate men in the ranks of the R A.F. in the same way that the term "men" is used in the Army.

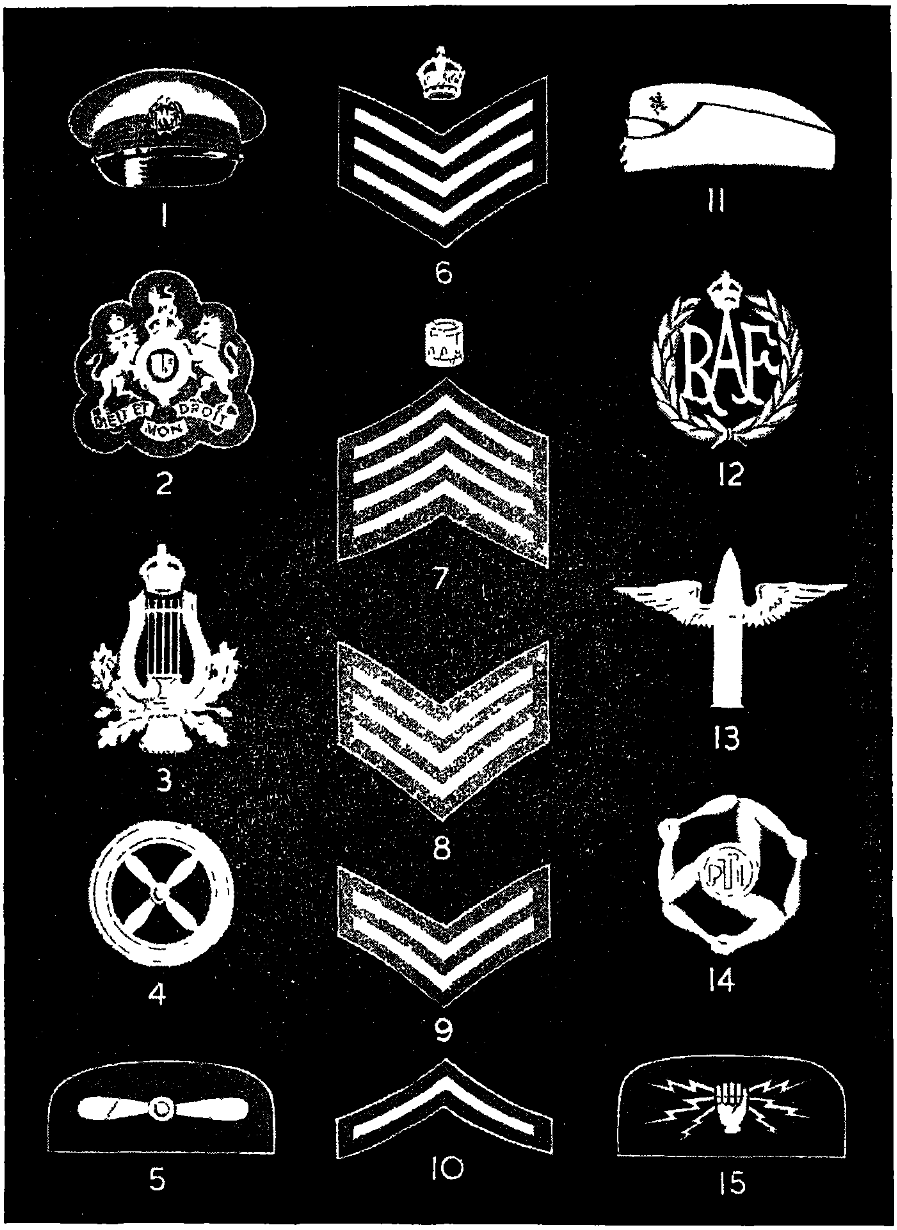
### PERSONNEL OF THE R.A.F.

The personnel of the R.A F. can be classified under eight principal branches. The most important of these is known as the General Duties Branch This is the Flying Branch All officers in this branch qualify as pilots, and it is from this branch that the executive and high-rank officers are chosen. Every officer who has to order pilots into the air is a qualified pilot himself, a fact that leads to close understanding between all pilots and their commanding officers The pilot ordered out on a difficult task knows that his commanding officer has first-hand knowledge of any difficulties he may be




CAPS, BADGES AND SLEEVE MARKINGS OF R.A.F. OFFICERS

**Fig. 9.** *1, Officers of air rank 2, Group Captain 3, Other officers 4, Service forage cap 5, Badge of officers of air rank 6, Pilot's badge 7, Observer's badge 8, Badge of officers below air rank 9, Chaplain's collar badge 10, Chaplain's cap badge 11, Medical officer's collar badge 12, Fleet Air Arm badge 13, Marshal of the R.A.F. 14, Air Chief Marshal 15, Air Marshal 16, Air Vice-Marshal 17, Air Commodore 18, Group Captain 19, Wing Commander 20, Squadron Leader 21, Flight Lieutenant 22, Flying Officer 23, Pilot Officer 24, Flight Lieutenant full dress*




CAPS, BADGES AND SLEEVE MARKINGS OF R A F AIRMEN

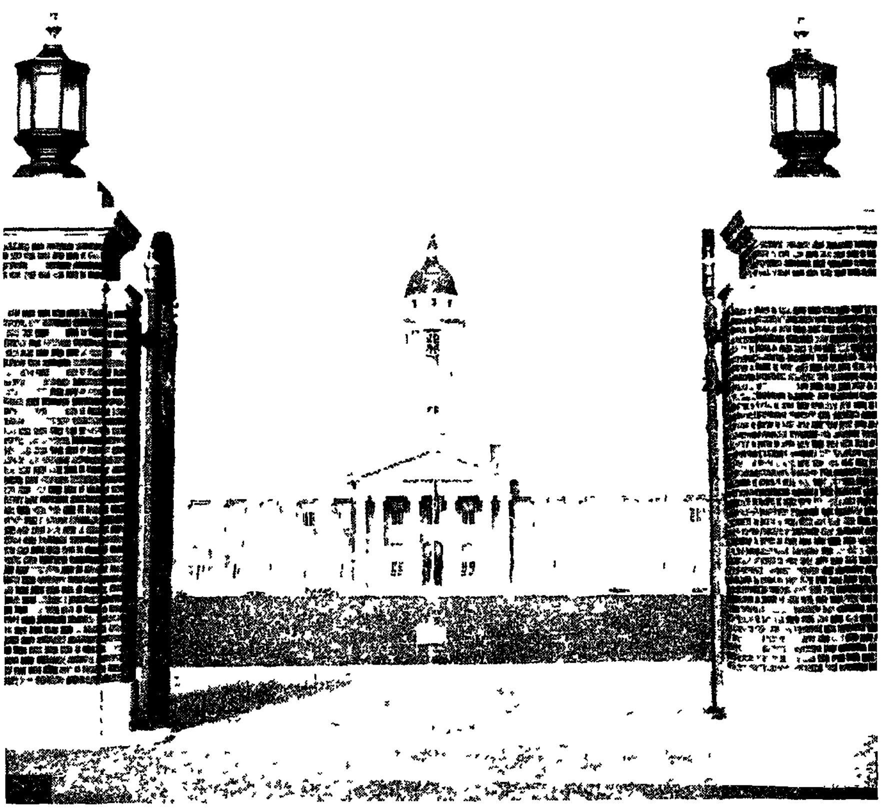
**Fig. 10.** *1, Ceremonial and walking-out cap 2, Warrant Officer's badge 3, Airman of the R A F band 4, Apprentice and Boy Entrant 5, Leading Aircraftman 6, Flight Sergeant 7, Drum Major 8, Sergeant 9, Corporal 10, Good Conduct badge 11, Forage cap 12, Cap badge 13, Air Gunner 14, Physical Training Instructor 15, Wireless Operator.*

facing On the other hand, the commanding officer can always appreciate the point of view of the pilots under him

*Up to the rank of group captain,* all officers of the General Duties Branch were required in peace time to put in a certain number of hours flying Above that rank the officer decided the matter for himself. There are two broad divisions in the commissioned officers of the R A F —those with permanent commissions and those with commissions for a stipulated length of time During a war, however, all commissions are granted "for the duration." Permanent commissioned officers are those who make the R A.F their life's career, and they enter at a young age as cadets at the Royal Air Force College, Cranwell.

*The second branch of the R A F is* the Administrative and Special Duties Branch. This covers such work as is concerned with armaments, balloons, engineering, intelligence, photography, and signals. The other branches are Equipment, Accountant, Medical, Dental, Legal, and Chaplains

As can be seen, an immense diversity of trades and professions is grouped into the personnel of the Air Force "Join the R A F. and learn a trade," was no idle imagining of the recruiting publicist.



CRANWELL COLLEGE, THE UNIVERSITY OF THE R A F
***Men who make the R A F their life's career enter this college as cadets at an early age.***

*A tutor explaining the theory of flight to a group of cadets at the R A F College, Cranwell*

Every airman in the Air Force is associated with some trade, and has an opportunity to become more or less skilled in that trade according to his abilities Apart from airmen concerned with such trades as butcher and cook, practically all men have work to do that is technical or is complementary to technical work. The pay of men varies with their trade and their degree of skill They have to attend training schools and pass tests before getting a transfer to a higher grade No chances can be taken, because on the skill of the airmen depend the efficiency of the aircraft and the safety of the crews

#### ORGANIZATION OF THE R A F

So much for the personnel of the Air Force Let us now look at its organization in greater detail The general organization of the R A F is based on the type of work that it is intended or expected to do in wartime To obtain a picture of this organization in relation to the numbers and types of aircraft required, the various aspects of the R A F.'s work must be dealt with separately

First of all, let us consider the Air Force as operating directly against an enemy air force. Here its work is first defensive, and the defence of Great Britain against aerial attack is probably the most important branch, as it is undoubtedly the most difficult, of that work

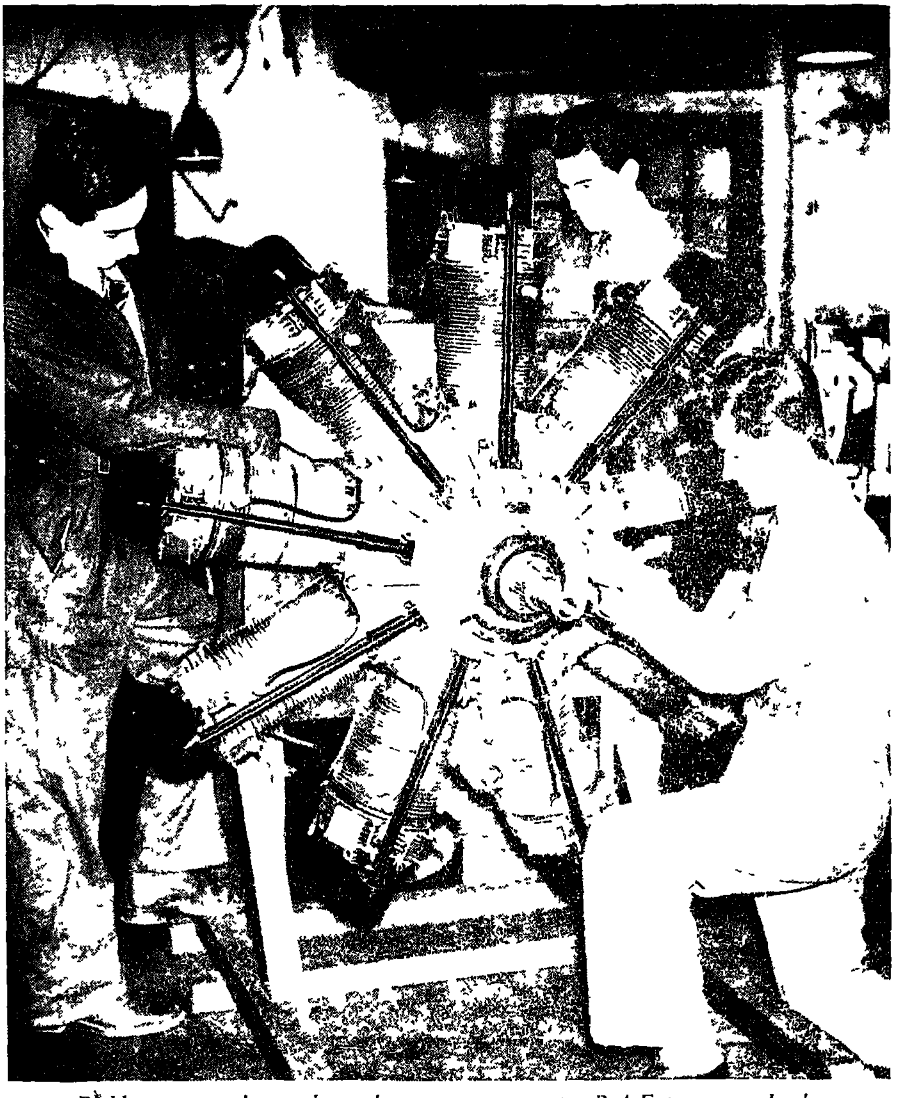
The fact that Great Britain is an island gives her no defence against aerial attack as it does against military attack The swiftness of aerial attack and the three-dimensional medium in which an air force works, make it far more difficult to ward off an attack by air than is the case with a naval attack.

The aerial defence of Britain is carried out by squadrons of the Fighter Command stationed at points near the coast and inland At these stations intercepter fighters are kept ready warmed on the aerodrome. Mechanics and pilots, ready dressed to take their places in the aircraft, wait nearby When orders come from the Central Control of Home Defence, the pilots clamber into their seats and the mechanics start up the engines Within a few minutes of receiving instructions the fighters are thousands of feet in the air climbing to meet the enemy bombers. Very large numbers of such fighters must be kept in readiness against mass attack by bombers.

Fighters of the Fighter Command are also kept ready on aerodromes behind the fighting lines. There is the difference,

however, that on the battle front the fighter goes into action against fighters of the enemy as well as against bombers.

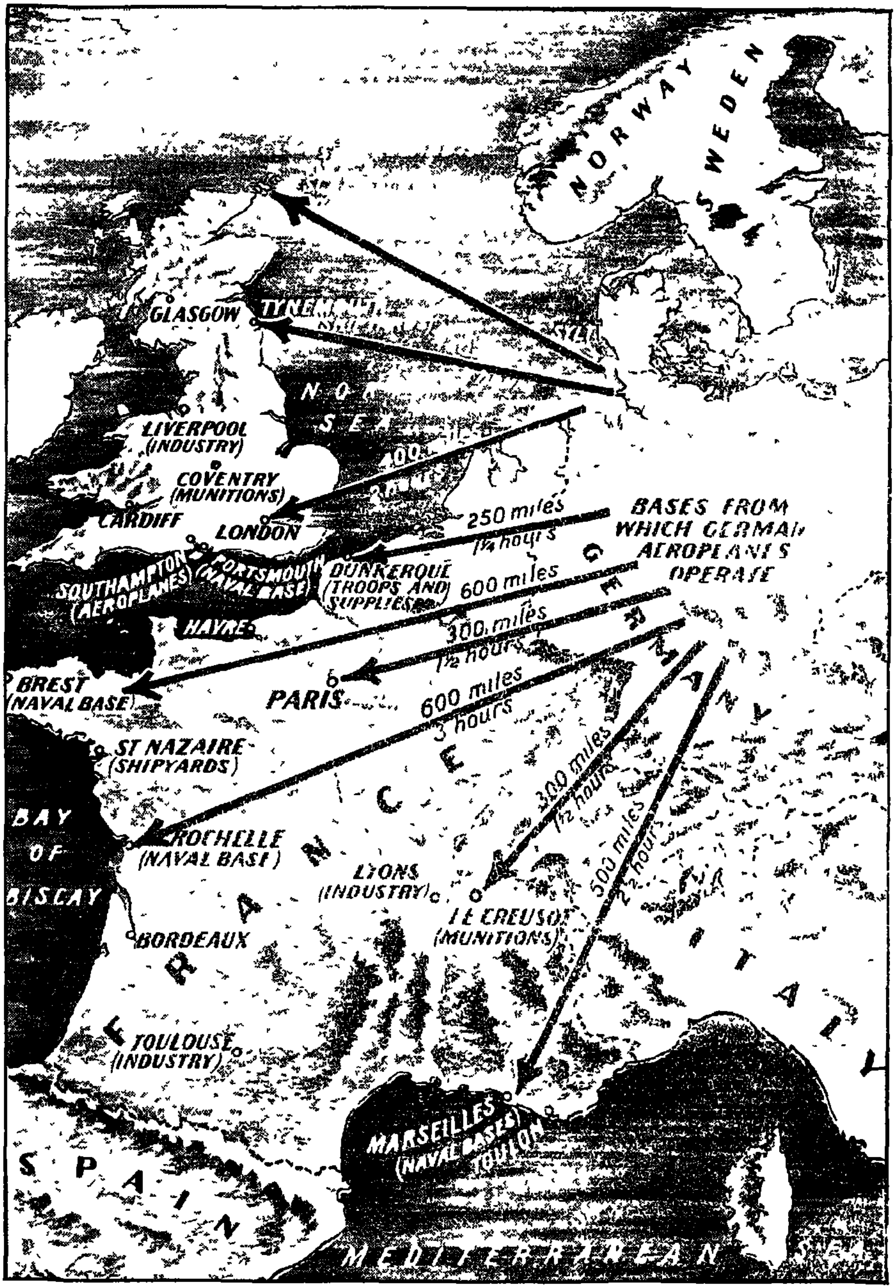
The bomber provides the offensive weapon of the air force as an independent fighting service But at the same time, the bomber, so far as the Home Front is concerned, is in a way a defensive weapon also. The bombing of military objectives, such as arsenals and munition factories that are situated away from a battle front, is only part of the bomber's duties It can also bomb aerodromes and seaplane bases and thus destroy enemy bombers before they begin their raids In this way the possession of strong bomber squadrons



*Budding airmen dismantling a large aero engine at a R A F training school*


DISTANCES FROM ALLIED BASES TO GERMAN OBJECTIVES

**Fig. 11.** *The comparative distances of objectives from British and French bases Comparison with Fig 12 reveals that the German bomber has to face greater distances.*




DISTANCES FROM GERMAN BASES TO ALLIED OBJECTIVES

**Fig. 12.** *The comparative distances of objectives in Britain and France from the principal German air bases. Compare this diagram with Fig. 11*

is a form of home defence. The work of the Bomber Command in connexion with the "security patrols" of the German seaplane bases (referred to in Chapter I) is typical

Although Britain and her ally France are both under certain strategic disadvantages *vis-à-vis* opponent Germany, from the point of view of aerial attack they have, on the whole, a distinct advantage. A comparison of the respective distances of objectives from bases, clearly shown in Figs. 11 and 12, reveals that German bombers face greater distances in reaching vital areas of Britain and France. In these drawings the distances are shown as the crow flies, and for convenience the existence of neutral countries has been disregarded for purposes of comparison.

So much for independent action. Let us now see how the R A.F. assists the Navy in its work. Some of it has already been described in dealing with the work of the Coastal Command. But this is not the only assistance which the R.A.F. could and would lend to the Navy.

Where strong enemy air action against the Navy near its home bases is attempted, it becomes the job of the R.A F. to counter such action, as far as possible, by engaging the enemy air force. The aircraft of the Fleet Air Arm cannot always be spared to deal with the enemy air force, and so this job remains for the R A.F to perform. (The Fleet Air Arm is dealt with in Chapter X.)

### AIRCRAFT AND NAVAL ACTIONS

In a large naval action, shore-based aircraft within range of a sea battle are a valuable factor whether the battle goes to the advantage of the British Navy or against it. Should the enemy fleet be in retreat to its base, and if ships were unable to follow, bomber aircraft could follow them and inflict such damage as might result in a decisive victory. On the other hand should the enemy have gained the advantage, a strong aerial attack might deter him from pressing it home and might prevent pursuit or enable additional ships to reach the scene of action in time to turn the scales

### ARMY CO-OPERATION WORK

Co-operation with the Army is similar in design For example, in a large-scale action on land, aircraft could follow up a retreating enemy and possibly change an ordered retreat into a rout. Action by bombers on important points behind the enemy lines could prevent them following up the advantages gained in a battle in which they had obtained the upper hand (Air Force co-operation with the Army is dealt with more fully in Chapter IV.)

This brief sketch of the R.A.F.'s activities indicates the great variety of tasks that it may have to perform In this variety lies an understanding of why its organization is of so flexible a nature The personnel are given as great an all-round training as possible so that they may be ready for any eventuality. This is the main reason why in the R.A.F the counterpart of the soldier's pride in his regiment is not so developed. The officers and men of the R.A F. devote their pride and loyalty to the Service as a whole, rather than to an individual part of it. At the same time many squadrons have built up traditions as strong as those of any regiment in the Army. With the older squadrons these traditions of service are often based on the exploits that have been remembered from the war of 1914-18.

Scarcely a single action on land or sea occurs without aircraft playing a part in it. The fine record of the R.A.F. in the early days of the war showed that the Service had reason to feel every confidence in its personnel. At the same time the personnel showed that it had every confidence in the machines and equip-

RAIDERS COMING OVER!

*Fighter pilots running to their aircraft on receiving a warning of the approach of enemy planes At aerodromes all over Britain during wartime fighter aircraft are kept warmed up ready to take off at a moment's notice The pilots on duty are dressed in their flying kit*

ment they were using. That this confidence should exist is of the utmost importance, and to inspire it there is a most elaborate organization within the R.A.F. to see that the standard of equipment and machines shall be of the best

In wartime, British aircraft are built to the same high standards as in peace time. Every single part has an Air Ministry number, is stamped with that number, and must be capable of passing detailed inspection and of standing up to the most rigorous tests

By maintaining such standards the R A.F is able to use the finest machines in the world The early months of war showed that its personnel, whether drawn from Britain or from the Dominions, is second to none. That superiority is due not only to the inborn qualities of British airmen but also to the detailed and careful training they are given.

EMPIRE AIRMEN DO THEIR BIT

*Australian airmen wheeling out a Short "Sunderland" flying boat These men were among the first Dominion airmen to reach Britain after the outbreak of war, September 3, 1939*

## CHAPTER III

# TRAINING THE FLYING PERSONNEL

THE R A F, as will have been gathered from the last chapter, consists of a number of groups of expert craftsmen each working closely together. The functions of every group are highly specialized and in consequence, the personnel of each group has to be carefully trained for the job they will be called on to perform.

In this chapter we are concerned with the training of the men who actually fly, or fly in, the aircraft that the R A F uses The work of the ground and maintenance staff is dealt with more fully in Chapter V

First, let us deal with the training of a pilot. The training of a R A F pilot differs from that of a civil pilot in as much as the R A F pilot first has to be taught to be a flier before he is trained to be a fighter For him flying is not an end in itself—it is simply the means that enables him to carry out his work as a member of a fighting service This principle operates throughout the whole training of pilots

### TRAINING A PILOT

The peace time training of the R A F pilot takes about two years from the time he first enters the Service until he is posted to a squadron His training is divided into three sections, elementary, intermediate, and advanced. In peace time the elementary training is given at one of the civil training schools that are under contract with the Air Ministry, the remainder of the instruction being given at a Royal Air Force Flying Training School Although the training scheme is slightly modified under wartime conditions, training is no less thorough and the pilot is taught just as much as he would be in peace time

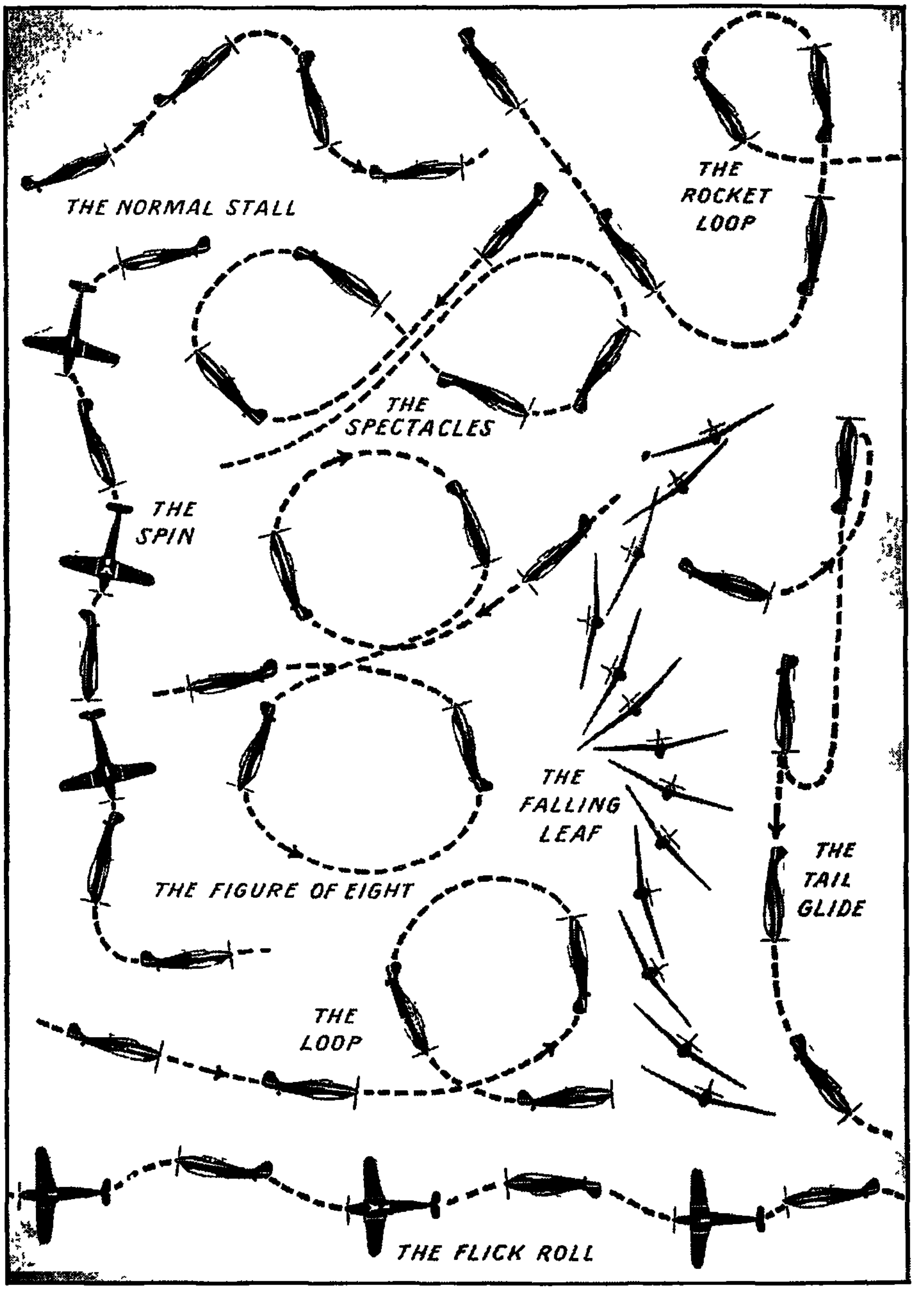
To meet wartime needs, the civil flying training schools were incorporated in the R A F before the end of 1939 as a new training department By intensifying the work done by pilots under training, the time taken for them to pass through their course was reduced to half

### LEARNING TO FLY

Let us describe briefly the principal features of that training Elementary training is as important as the later training, because it is during this period that the vital foundations of good flying are permanently laid

The chief aim is to teach the pilot to use the controls of his aeroplane in a smooth but confident manner, so that he may benefit to the full from more advanced instruction At the same time he has to learn at ground lectures the reasons for all he does in the air Ground instruction is kept in advance of instruction in the air so that the pupil fully understands new aerial manœuvres when he comes to carry them out. He learns about engines and airframes, so to understand the maintenance work carried out on all aircraft.

In addition to learning all the normal flying manœuvres—landing, gliding, and turning—the pupil also learns during his elementary training some aerobatic manœuvres, such as looping and rolls Some typical aerobatics are shown in Fig 1 He is also taught how to carry out simple blind flying with the aid of




TYPICAL AEROBATICS

Fig. 1. *Some typical aerobatics that every qualified pilot must be able to perform with almost automatic precision before he joins his squadron.*

instruments. When learning blind flying the pupil is enclosed by a hood so that he cannot see the horizon, while the instructor sees to it that his pupil comes to no harm. (This hood can be seen in Fig 3 )

The main object of elementary instrument flying, as blind flying is properly called, is to give the pupil a thorough grasp of the aids to flying that he will use when visibility is bad. For example, when the horizon is obscured, a pilot cannot determine by sight alone whether his aeroplane is level or whether it is flying with the port or starboard wing low.

### ELEMENTARY TRAINING

Elementary training includes simple navigation, such as map reading, following a compass course, and allowing for drift produced by wind Navigation training and instrument flying however, are never pushed ahead at the expense of a thorough grounding in the correct and almost automatic control movements necessary in flying.

The flying controls consist of the rudder and control column or "joy stick" (Fig 2). The rudder is operated by the feet and causes the nose to turn to right or left. When the control column, which is operated by hand, is moved forward, the nose drops and the aircraft descends, and vice versa By moving the control column to the right or left the aeroplane is caused to bank to the right or left respectively But a simple bank of this nature does not cause the aeroplane to turn properly. As with almost all manœuvres in the air a correct turn requires the use of all three movements of the controls, in the correct degree and sequence, and at the right time. It is these combined movements of

YOUNG AIRMEN LEARN THEIR LESSONS

*Pilots studying maps before taking off at a R A F training school Map reading, essential to accurate navigation, is an important part of every pilot's training*

NAVIGATION CLASS IN THE OPEN AIR
*These airmen are being instructed in the use of the bubble sextant With this instrument which measures the angle of the sun, an aircraft s position can be calculated*

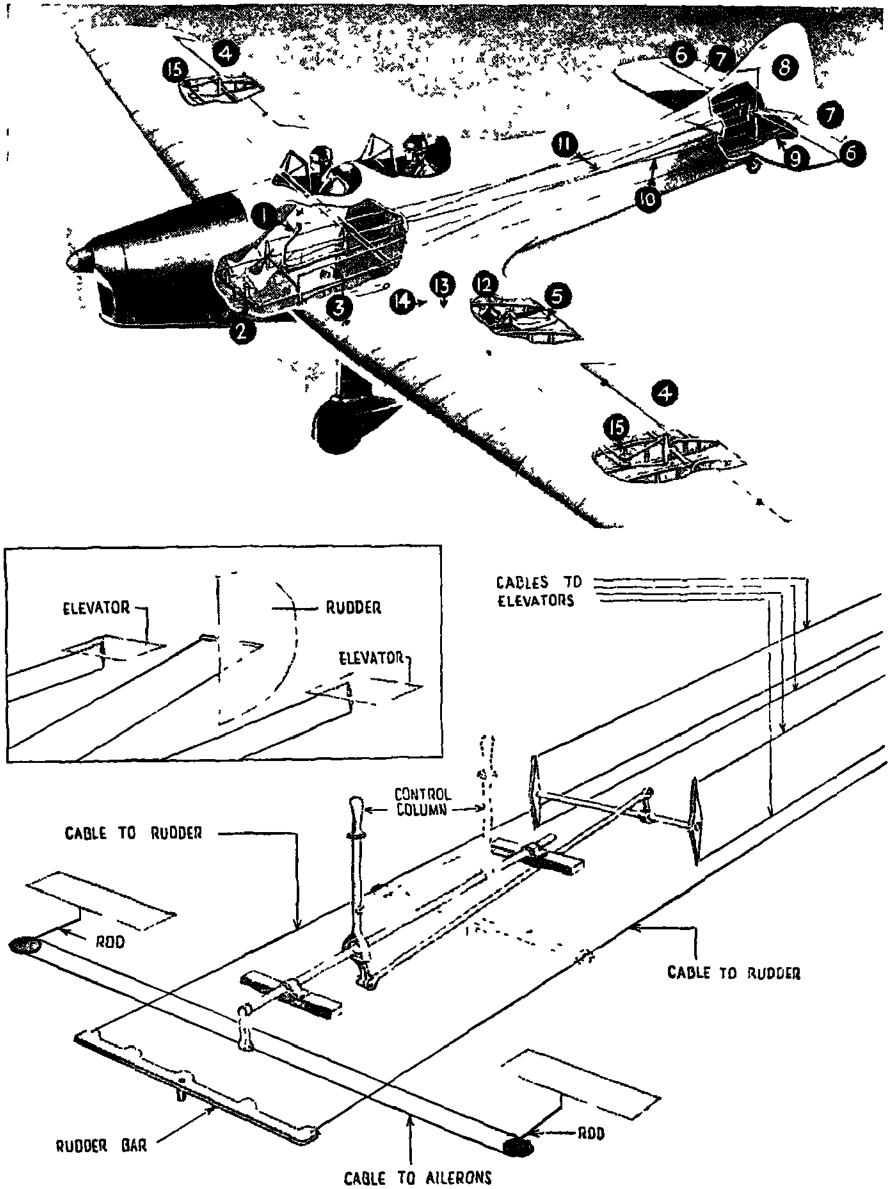
the controls that are taught with so much care For elementary training, light aircraft are used of the monoplane type, such as the Miles "Magister" (Fig 3)

Once a pilot has satisfied his instructors as to his proficiency in his training up to this point, he is transferred to an intermediate school. Here, the first thing that he learns is to fly various Service types of aircraft, or advanced trainers.

### TRAINING AIRCRAFT

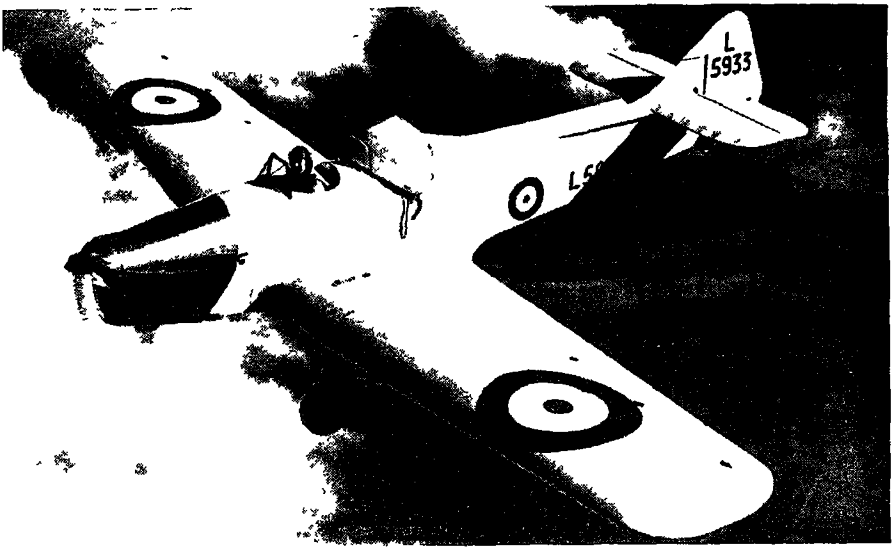
These latter are very similar to Service type aircraft, such as the Miles "Master" or the Avro "Anson" The Miles "Master" (Fig 4) is a single-engined monoplane, and the Avro "Anson" (Fig. 5) a twin-engined monoplane. Two other types of aircraft used to a great extent are the North American "Harvard" and the Airspeed "Oxford." The "Harvard" (Fig. 6) an advanced trainer of the single-engined type, is a low-wing monoplane—that is, a monoplane with the wing attached to the lower part of the fuselage or body of the aircraft. Its speed is nearly 200 m.p.h. The "Oxford" (Fig. 7) is a twin-engined trainer, also of monoplane design, and is a development of the commercial air liner known as the Airspeed "Envoy." The Miles "Master" is the fastest of the trainers, however, having a top speed of about 270 m p.h

Before the beginning of intermediate training, however, a general decision must be made of the type of aircraft the pilot will eventually fly in the Service,




CONTROLS OF AN AEROPLANE

**Fig. 2.** (*Top*) *1, Control stick 2, Rudder bar 3, Tail trim wheel. 4, Ailerons 5, Trailing centre wing flap 6, Elevators 7, Tail trim 8, Rudder 9, Tail trim cables 10, Rudder cables 11, Elevator cables 12, Flap operating vacuum cylinder 13, Aileron balance cable 14, Aileron operating cables. 15, Pulleys* (*Below*) *Diagram of the control system of an aeroplane The dotted lines show how dual control operates*




BLIND FLYING IN A TRAINING AIRCRAFT

**Fig. 3.** *The Miles "Magister," a light single-engined monoplane used for elementary training Notice the hood that conceals the pupil while he is learning blind flying*

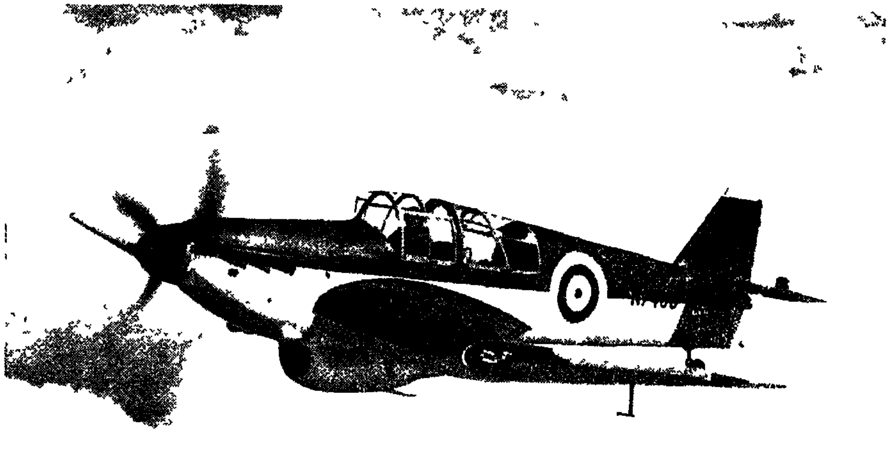
because, from now on, this will have an effect on the course of his training.

For instance, if the pilot is to serve with a fighter squadron—and as far as possible his personal preferences are taken into consideration—he will learn on single-engined trainers Similarly, if a pilot is to go to a bomber squadron he will learn on twin-engined trainers It says much for the thoroughness of the elementary training that pilots can at this stage be transferred direct from the single-engined machines of the elementary school to twin-engined aircraft. After a few hours instruction on the new types most pilots are able to fly them solo.

### INTERMEDIATE TRAINING

During the intermediate term of flying the pilot changes over gradually from "direct" flying instruction to "indirect." That is to say, instead of his training being directly concerned with the handling of his aircraft, he is still gaining experience of such handling while engaged on duties other than the mere flying of the aircraft. This is most important because by the time the pilot passes to advanced training he must have reached a point where the handling of the aircraft is subconscious or automatic. Otherwise he cannot give his full attention to the military considerations involved, such as reaching an objective and bombing it.

As during the elementary training, so during intermediate training the pilot has much to learn on the ground. This ground instruction proceeds side by side with instruction in the air, and includes a wide variety of subjects. The pilot has to become fairly advanced in navigation and this subject includes a knowledge of meteorology. While many of the larger aircraft carry their own navigators in addition to the pilot, it is imperative that the pilot should have a thorough understanding of navigation even if he does not actually perform a navigator's duties while in the air. On single-seater aircraft, and other small aircraft, of course,



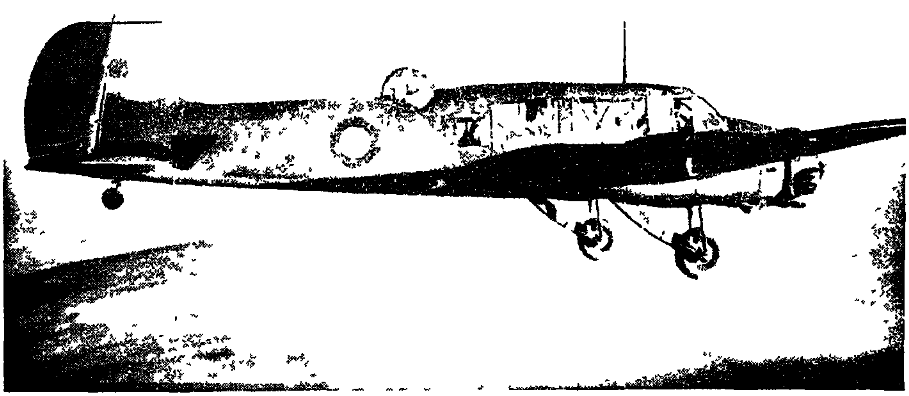
MILES "MASTER" TRAINING MONOPLANE

**Fig. 4.** *This very fast single-engined machine is used extensively during intermediate training by pilots who are destined to join fighter squadrons when fully trained*

the pilot will have to do all his own navigating

During his intermediate term the pilot has also to learn the principles governing bombing, reconnaissance work and the use of machine guns He must also learn something about the construction and maintenance of engines and airframes Side by side with this ground instruction, practical instruction on the same subjects will be going on in the air

Advanced clear-weather, instrument, and night flying will be learned concurrently, in such a way that the pilot will



AVRO "ANSON" TRAINING MONOPLANE

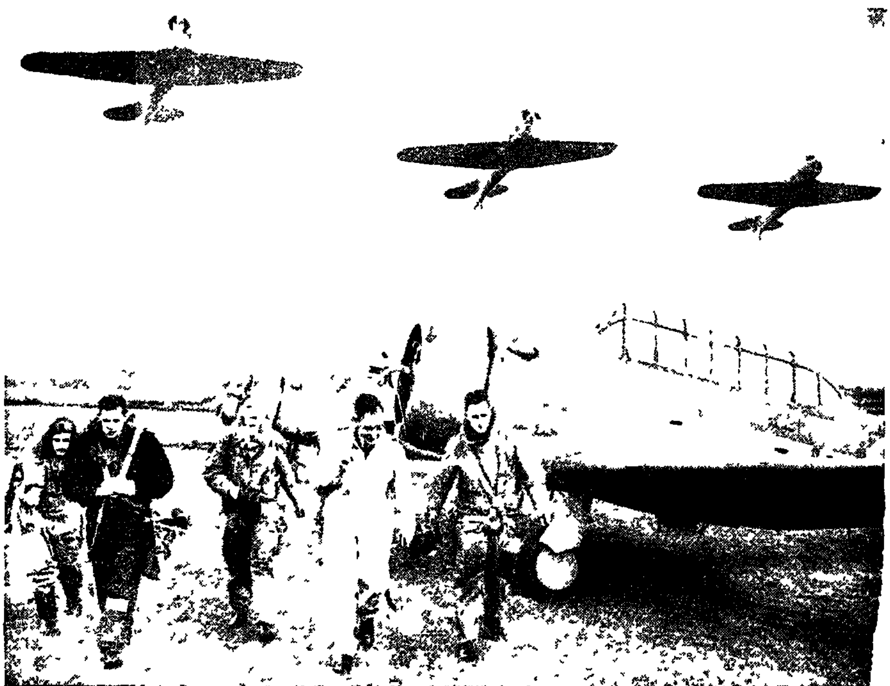
**Fig. 5.** *The Avro "Anson," a twin-engined monoplane used during intermediate training by pilots who will eventually qualify for work with bomber squadrons*

cease to consider these as different types of flying. On active service flying a pilot may start out in clear weather, pass through a patch of clouded conditions, and complete his flight after dark He must therefore learn that the three types of conditions merge into one another and are complementary

### FORMATION FLYING

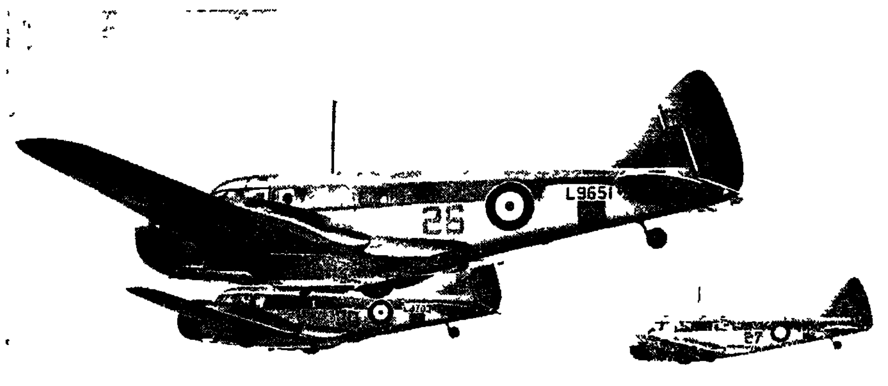
The pilot is also introduced to formation flying. At first this is carried out only for short periods because the intense concentration required is very tiring. In formation flying the pilot has to keep his eyes fixed on the next machine in the formation either to the side or ahead of him He has to follow that aircraft and maintain his position by the constant movement of his flying controls and by constant adjustment of the throttle control of his engine (*see* Fig. 12, page 2[illegible]). If he drops behind a little he must open up his engine to catch up, but the throttle must be closed down again before the right position is attained because aircraft have no brakes and there is the danger that the extra speed of the aircraft will cause it to overrun its position. Gradually, with constant practice, the necessary skill is attained During intermediate training the formations are never as close as in advanced training

By the end of his intermediate training a pilot will be able to reach any given objective in almost any weather. He will be able to complete a triangular course entirely with the aid of his instruments only, arriving back at the aerodrome of departure without once having lifted the



FUTURE PILOTS SHOW THEIR PACES

**Fig. 6.** *Pilots returning from a flight in "Harvard" aircraft at one of the advanced training schools As they walk from their machines three "Harvards" roar overhead*




A FLIGHT OF AIRSPEED OXFORDS

ig. 7. *These aircraft are used extensively at advanced training schools By the time he has finished his advanced training a pilot is ready to join his squadron*

ood that covers him He will also be ble to recover from spins and other un- sual positions by the aid of his instru- ents alone

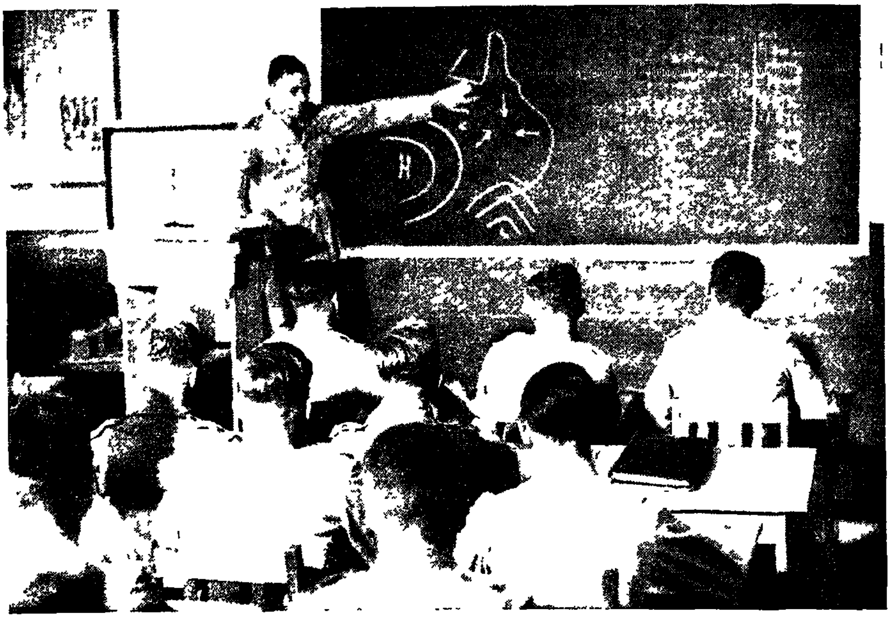
Finally, he will have passed various ests, amongst them a high flying test Modern bomber and fighter aircraft fre- quently operate at very great heights— ometimes as much as 30,000 feet At hese great altitudes the cold and the arity of the atmosphere combine to test he stamina of airmen most exactingly Despite the aids of special warm clothing in some cases electrically heated), the cold is still so intense that only men of exceptional fitness can stand it At great heights oxygen cylinders are used to supplement the deficiency in the rarefied ir But oxygen cannot correct the greatly educed atmospheric pressure that, by cting on the blood stream, occasionally esults in temporary losses of conscious- ess, vomiting and other serious effects uch effects, it can readily be imagined, ay be disastrous to airmen and it fol- ws that all who propose to fly the rcraft of the R A F must pass a rigor- is test of their ability to stand up to the nditions encountered in high flying

On the successful completion of his intermediate training, the trainee is pre- sented with his coveted wings, denoting that he is an accomplished pilot He is not yet a fully-fledged fighting pilot,

*Royal Air Force Official*

OXYGEN APPARATUS

*A pilot wearing his oxygen mask essential for altitude flying A microphone for his radio-telephone is fitted into the mask*



AUSTRALIAN AIRMEN STUDY METEOROLOGY

*Pupils in Empire training schools, as in Britain, are obliged to master all kinds of complicated subjects from navigation to meteorology before finally earning their wings*

however, and will not be until he has successfully completed his period of advanced training.

Advanced training is designed to teach a pilot how to carry out the duties that will be his when he joins his squadron

It follows that it is largely concerned with armaments of aircraft, their operation and with bombing. The amount of ground work is less than in the previous periods of training for the pilot is now concerned with the practical applications of what he has already been taught

### VARYING WORK OF PILOTS

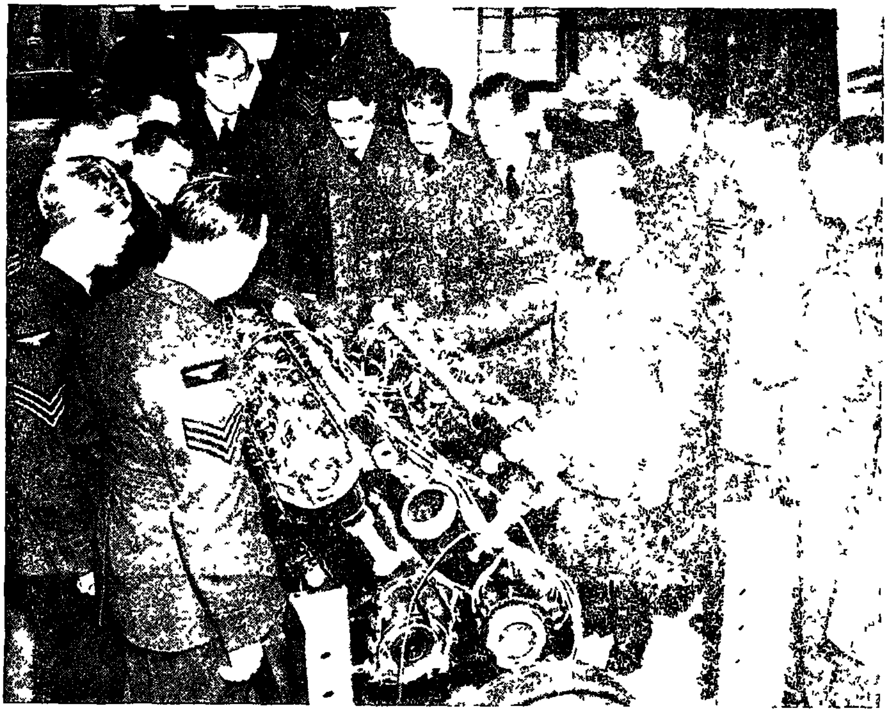
Although much of the work is common to all pilots, the work of the individual is varied according to the type of squadron for which he is destined. Thus, the fighter pilot will not be concerned as much with bombing, whilst the pilot of heavy bombers will not be concerned with the tactics employed by fighter pilots in aiming their machine guns.

During the term of advanced training, pilots fly together as crews, without instructors, whenever possible In this way they learn the duties and the points of view of the other members of an aircraft's crew, they learn to co-operate with them, and to rely entirely on their own judgment and initiative. For instance, one pilot may act as observer or gunner for another pilot who is flying the aircraft.

Soon after he begins his advanced training the pilot is introduced to the camera gun, used for preliminary instruction in machine gunning whether the firing be at a ground target or at another aircraft in the air. The camera gun (Fig. 8) is handled, sighted and "fired" in the same way as is a real gun, but instead of bullets being fired when the trigger is pulled, a piece of film is

exposed. When this film is developed it gives a picture from which can be estimated the exact spot on the target that each bullet, or burst of bullets, would have hit had live ammunition been in use By studying these photographs at leisure on the ground, the pilot is helped to understand any errors he may have made Targets for practice firing in the air are also used. These often take the form of a kind of wind-stocking towed by an aircraft (*See* illustration page 99.)

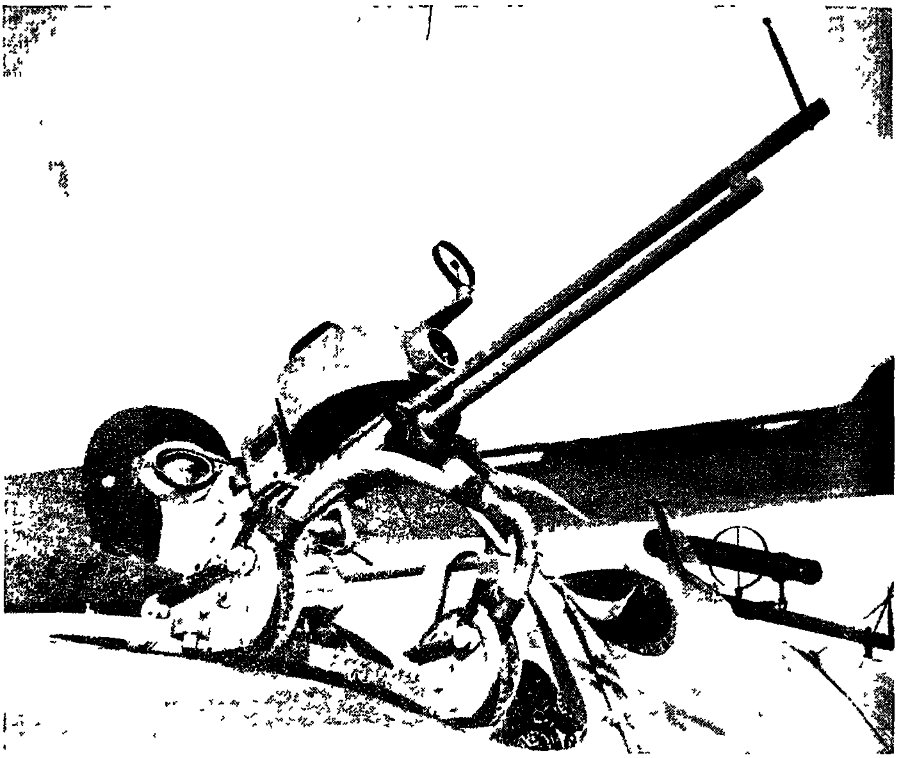
It is during this period of training with the camera gun that approach tactics of fighters are taught Various methods of attack are practised, such as diving on to the target from above and also coming up to the target from below. (These tactics have already been dealt with in Chapter I ) When a sufficient degree of skill has been attained, the pilot goes to a "shooting range" where firing is carried out with bullets fired at targets both in the air and on the ground The wind-stocking type of target is dropped on the aerodrome after being fired at and inspection (Fig 9) reveals the number of hits obtained by the pilot.



INSTRUCTION ON THE AERO ENGINE

*A group of pilots being taught the principles of construction of an engine All pilots receive training in the construction and maintenance of engines and airframes and so are able to carry out whatever simple running repairs may prove to be necessary*

The operation of movable guns is also part of the training of a pilot The reason is that not only does it help him to appreciate the difficulties of his own gunners, but every member of a crew may at some time be called on to man a gun. Details of some typical guns used on British aircraft and the turrets in which they are



PRACTISING WITH THE CAMERA GUN

Fig. 8 *This is sighted and fired exactly as an ordinary machine gun, but instead of firing bullets, a film is exposed and registers the "hits" on the target*

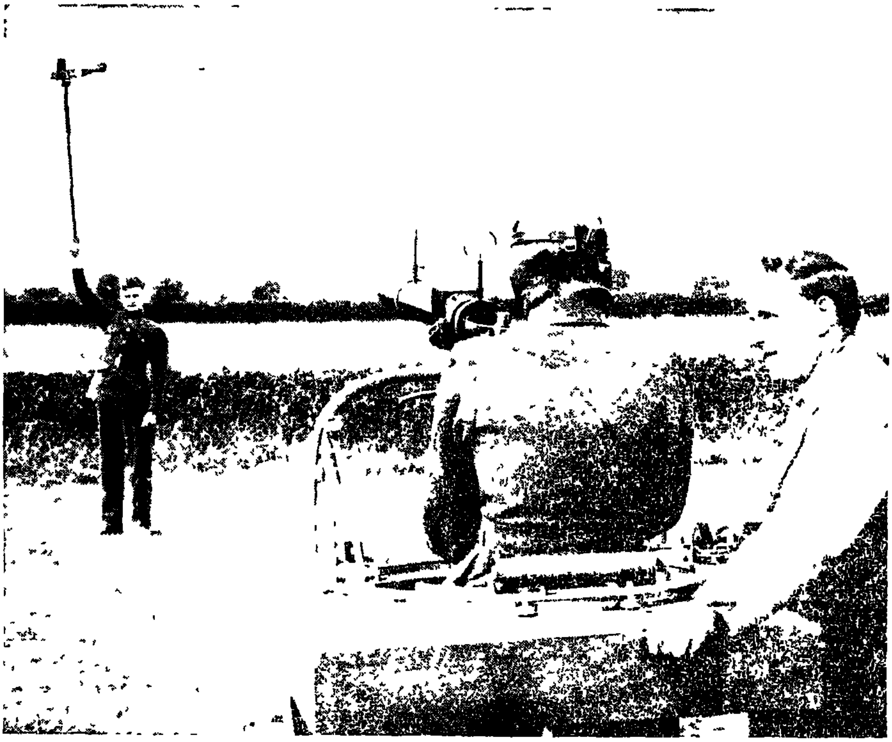
operated are seen in Fig 10 (page 101)

Gun training begins on the ground and several types of guns may be used on the same range (Fig 11) Sometimes a pilot may be acting as second or reserve pilot on a large aircraft As such, his duties may normally be those of navigator, but should one of the gunners be wounded, the second pilot would be called on to take over his gun turret

**BOMBING TRAINING**

The intricacies of bombing sights and methods of allowing for wind drift and the speed of the aircraft are taught during advanced training, and practice bombs are dropped on ground targets Dive bombing is also covered In this the aircraft dives on to its target, releasing the bombs near the bottom of its dive before climbing steeply These subjects are described in more detail in dealing with the training of an observer (*see* page 103) Additional formation flying, reconnaissance work, the use of radio, and further high flying are carried out

When the pilot leaves the advanced training school he is ready to take his place as a useful member of his squadron, but this does not mean he has no more to learn He has to learn the tactical work of his squadron and how to co-operate with the other pilots when carrying it out. During wartime such work may well be learned while engaged on active service, the new pilot gradually becoming fully

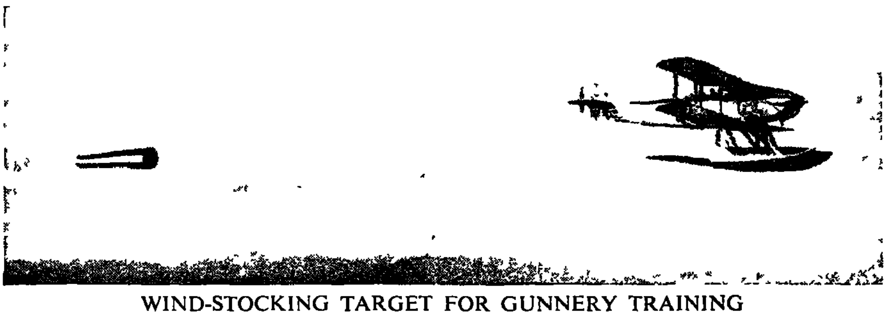


SHOOTING FILMS NOT BULLETS

*An gunner receiving instruction in sighting a camera gun A model aeroplane on a pole is used as a target and is moved to simulate the flight of an aeroplane*

experienced by taking part in more and more important and dangerous activities of his squadron But his training will have been such that no matter how inexperienced he may be in active service flying, he can never be considered a "passenger" in the squadron

Pilots destined for those branches of the Royal Air Force in which some specialized knowledge is required will



WIND-STOCKING TARGET FOR GUNNERY TRAINING

*A wind-stocking type of target being towed by an aeroplane Budding air gunners of the R A F train by shooting at these wind stockings from other aeroplanes.*

receive a further training course before they join a squadron. Obviously, pilots for flying boats used by the Coastal Command must go through a course in the handling of flying boats. This requires a sufficient knowledge of seamanship to ensure that the aircraft may be handled properly in different conditions of tide and wind Similarly, something of the specialized work of Army Co-operation squadrons must be learned by Army Co-operation pilots before they join their squadrons. (Details of this work are given in Chapter IV.)

### SYSTEM OF R A F TRAINING

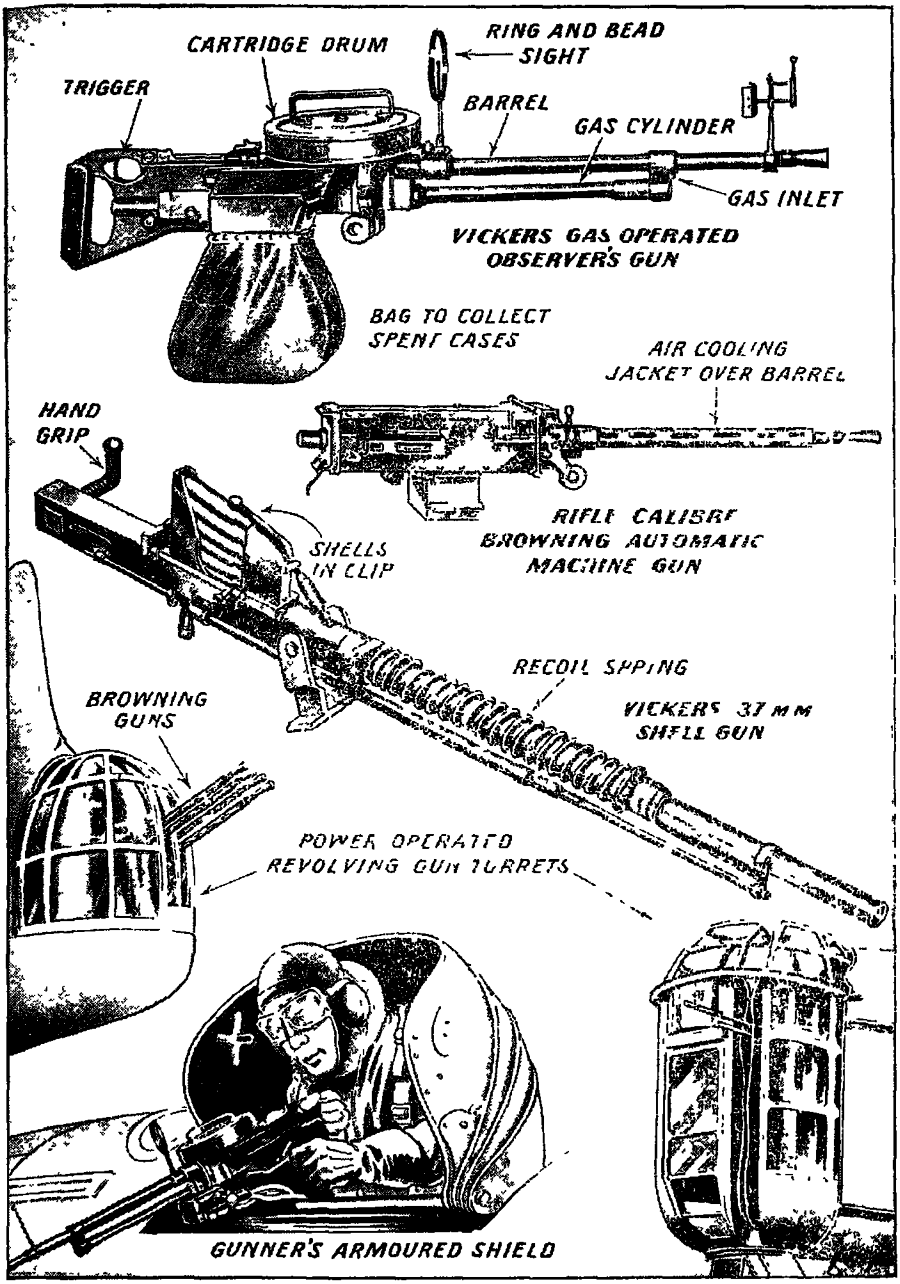
The system of training in the R.A F. aims at turning out pilots trained in a uniform manner, but not—be it noted—to a uniform standard of skill Individual talent is encouraged and developed to the full. All pilots selected as instructors, at least during peace time, must have served some time with a squadron. Inevitably they must be excellent pilots in all ways, and at the same time must have those qualities of temperament and skill so necessary to the instructor Pilots chosen as instructors pass through a special course at the Central Flying School.

One big advantage of a standardized form of training is that pilots for the R.A F. may be trained in different parts of the British Empire, and yet be ready to take their place in squadrons alongside pilots trained in this country. The many advantages in wartime of training pilots overseas were not overlooked Indeed, a most comprehensive scheme for training pilots in other parts of the Empire was evolved before September, 1939.

Because of the danger of attack from

SEEKING PROOF OF THEIR MARKSMANSHIP

**Fig. 9.** *Pupils examining a wind-stocking target for results of their practice machine gun fire These targets are towed behind aeroplanes, as seen at the bottom of page 99*




THE "STING" OF AN AIRCRAFT

**Fig. 10.** *Above, three typical British aircraft guns These types are mainly used to defend bombers. Below, are two types of gunners' turrets and a protective shield.*

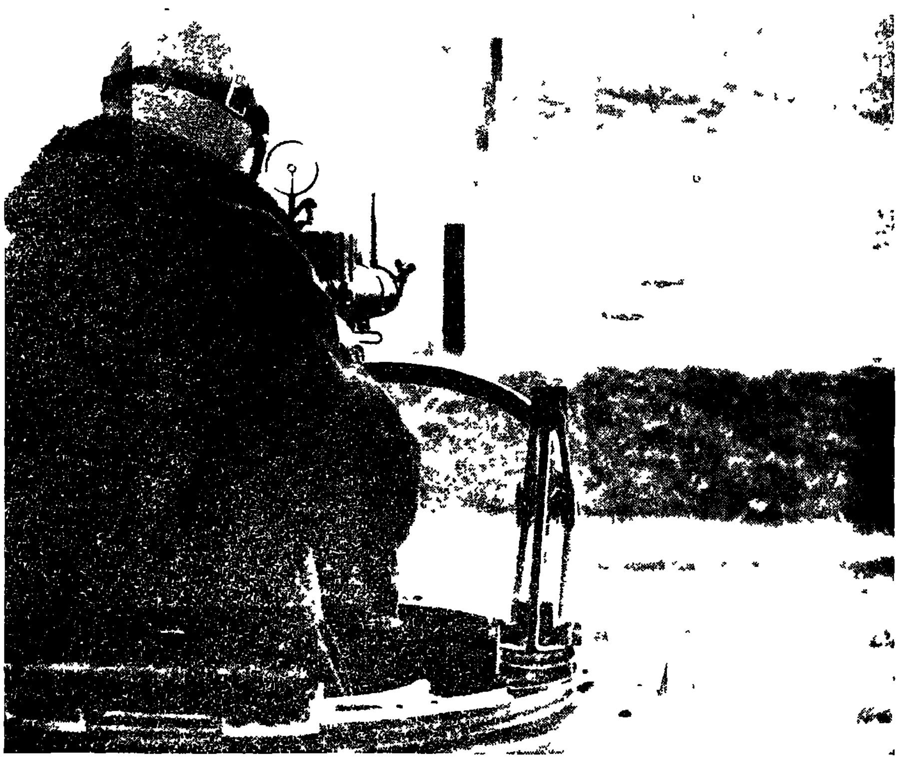


Fig 11. *R A F. gunner training on a range with a Lewis gun Note the target*

enemy aircraft, it was necessary, at the outbreak of war to restrict all non-military flying in the eastern half of the British Isles. This restriction meant that all flying training in Britain had to be performed in the western area. For elementary training this was no great drawback because long-distance flying does not figure much in such training, but this restriction on flying quite obviously increased the difficulties of intermediate and advanced training.

### CANADIAN TRAINING SCHOOLS

For this reason it was decided to open numerous intermediate and advanced training schools in Canada. The advantages of Canada for this purpose are that it is admirable for long-distance flying, and that training can be carried out without interruption from enemy aircraft. Thus, many pilots receive their elementary instruction in Britain, proceed to Canada to complete their training and return later to take their place in the R.A.F as fully qualified pilots.

### EMPIRE TRAINING SCHEMES

As the cost of training centres is lowered if they can be concentrated in one country, a parallel training scheme was drawn up with Australia and New Zealand Under this scheme, pilots receive their elementary training in these countries and then also proceed to Canada. One advantage of pilots receiving elementary training in their own countries is that should there be any question of their not making good pilots, this fact will have been discovered by the time

their elementary training is completed.

In the case of South Africa, which is also taking part in the Empire training scheme for pilots, it has proved desirable for the whole of the training to be carried out in that country The system of training and most of the types of aircraft used there, however, are the same as those in the other parts of the Empire

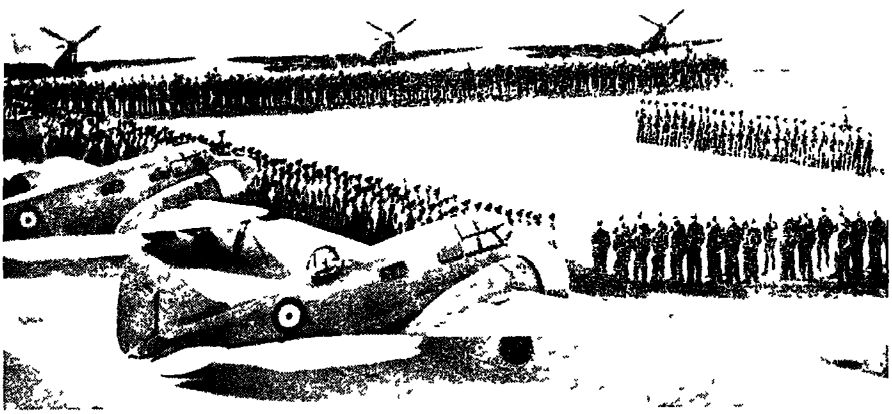
### WORK OF THE BOMBER CREW

Let us now turn to the training of other members of the R A.F. flying personnel. Although the work of the pilot of an aeroplane is perhaps most in the public eye, the work of the other members of the aircraft crew is equally important These crews take the same risks as the pilots, and the same care is given to their training although naturally their training courses do not last so long

First, the observer The grade of observer was common in the war of 1914-18 but was dropped after that war It was revived again a few years ago and is today an important grading An observer can be recognized by the gilt letter O with one wing attached, that is worn above his left-hand breast pocket. An observer has some training in all the duties that have to be carried out in an aeroplane other than that of actual flying. He is skilled in navigation, photography, gunnery and bomb aiming and even has some knowledge of radio although wireless operating is a branch with which an observer is not closely concerned

### TRAINING IN NAVIGATION

Navigation is probably the most important of his duties, for with the numerous mechanisms of the modern bomber the pilot's time is fairly fully occupied On long flights the navigator is working



AT A CANADIAN TRAINING SCHOOL

*Men and machines parade at a training school at Trenton in Canada There are now many of these schools in Canada and they will turn out 10,000 fully-trained pilots every year On account of the fact that the country is ideal for long-distance flying and interruption by enemy aircraft is non-existent, many pilots receive their elementary training in England, then proceed to one of these Canadian schools for intermediate and advanced training*

AUSTRALIAN AIRMEN WITH THE COASTAL COMMAND
*Australian pilots receive their initial training in Australia, then they go to Canada to complete their course These airmen are part of the crew of a Short "Sunderland" flying boat.*

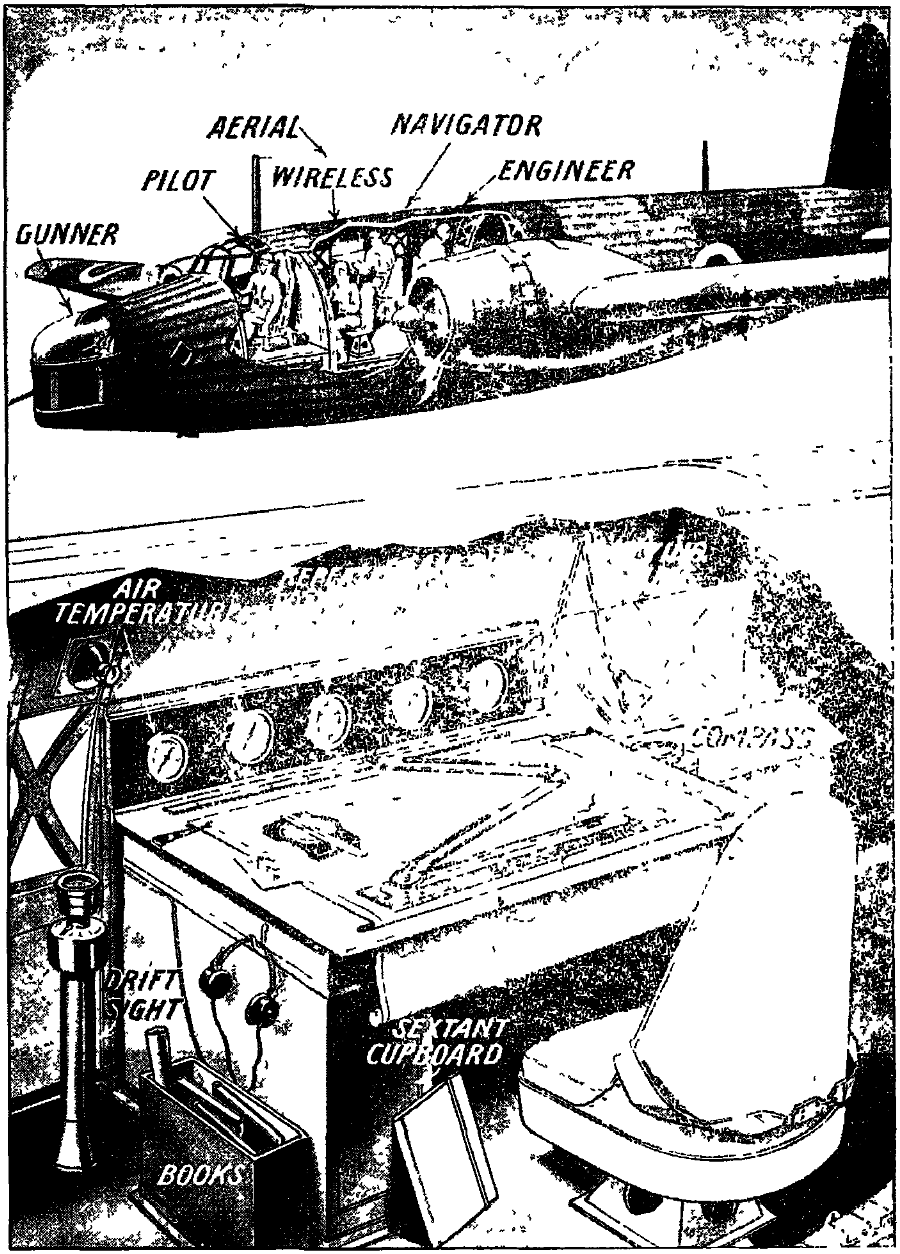
out the course of the aeroplane continually and checking its position, and in larger aircraft he is provided with a special table on which to work (Fig 12).

**OBSERVER'S GUNNERY TRAINING**

Except for the operation of fixed guns, the observer's training in gunnery is carried out on much the same lines as a pilot's. When an observer is called on to fight with a gun, it will generally be one in an enclosed turret (Fig. 10), so his training covers all details of gun turrets and the operation of their guns Some gun turrets have a single gun, others multiple guns, and the turrets are almost invariably operated by some form of power-driven mechanism

The observer begins his training with navigation, and from the start he flies in aircraft so that he soon becomes accustomed to working in the air Naturally, he also has much work to put in on the ground, for to be a good navigator he must study meteorology and learn to forecast weather conditions An important part of his work concerns the estimation of wind direction and velocity while in the air. Although he will have some information about the wind when he plots his course at the start of a flight, wind conditions will probably change as the flight progresses.

Unlike the navigator of a commercial air liner in peace time, he cannot rely on radio for weather reports. For one thing, weather reports about conditions over or near enemy territory are not available; and for another, radio contact between bomber aircraft and base cannot be maintained during wartime. Such contact might disclose the positions of the




DISPOSITION OF CREW IN A BRITISH BOMBER

**Fig. 12.** *Above is seen the disposition of the crew in a typical bombing aircraft. In large bombers the navigator is given a special table (below) at which to do his work*

aircraft to the enemy or warn him of an intending raid.

As soon as he is fairly proficient in navigation, the observer is sent up with a pilot to carry out reconnaissance practice. He may be sent to intercept a train at a certain point at a given time He must arrive at that point at the right time and photograph the train as it passes The photographs will indicate whether the aircraft could have bombed the train had it been on active service

### SPOTTING FROM THE AIR

While learning navigation, the observer is also taught how to spot important details that have to be noted in reconnaissance work. This is not so simple a job as might be thought. Modern camouflaging of troops and equipment on the ground means that the observer must rely on signs that suggest things rather than on observation of the actual objects themselves Shadows cast by buildings play an important part in this work, and the observer must learn how to distinguish them and to understand what they mean

The observer also learns the complicated art of aerial photography. He is taught first to photograph single objects and later the details of mapping photography in which strings of overlapping photographs of the ground are taken. (Aerial photography is dealt with in detail in Chapter V.)

The observer's association with radio is mostly connected with direction finding work (Fig. 13) because he will have to use this method at times to check the position of his aircraft By means of a loop aerial on the aircraft, the bearings of two known stations on the ground are taken. These bearings are plotted as two lines on a map and the point where they intersect reveals the aircraft's position

The observer naturally is required to train in night flying because he must be

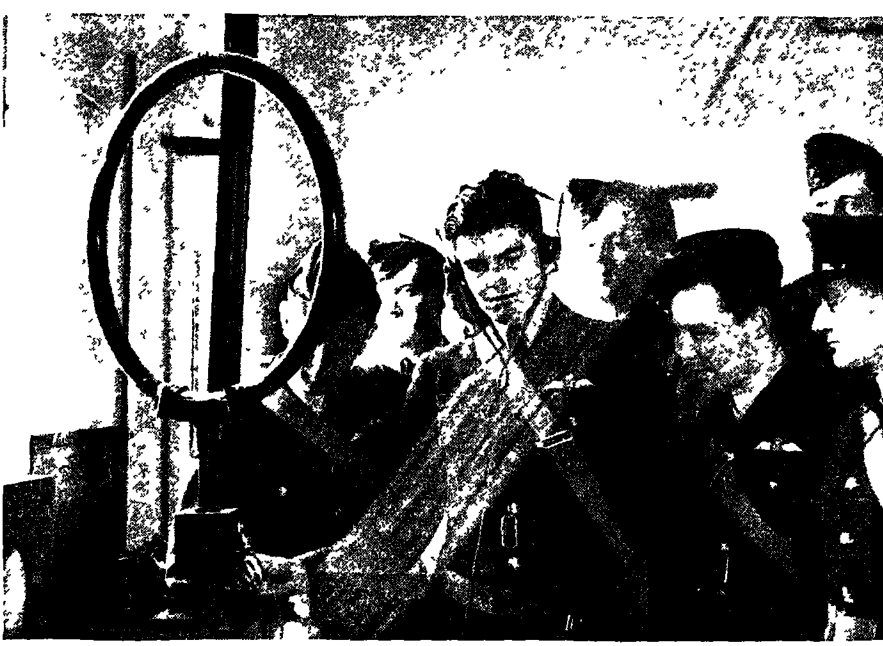
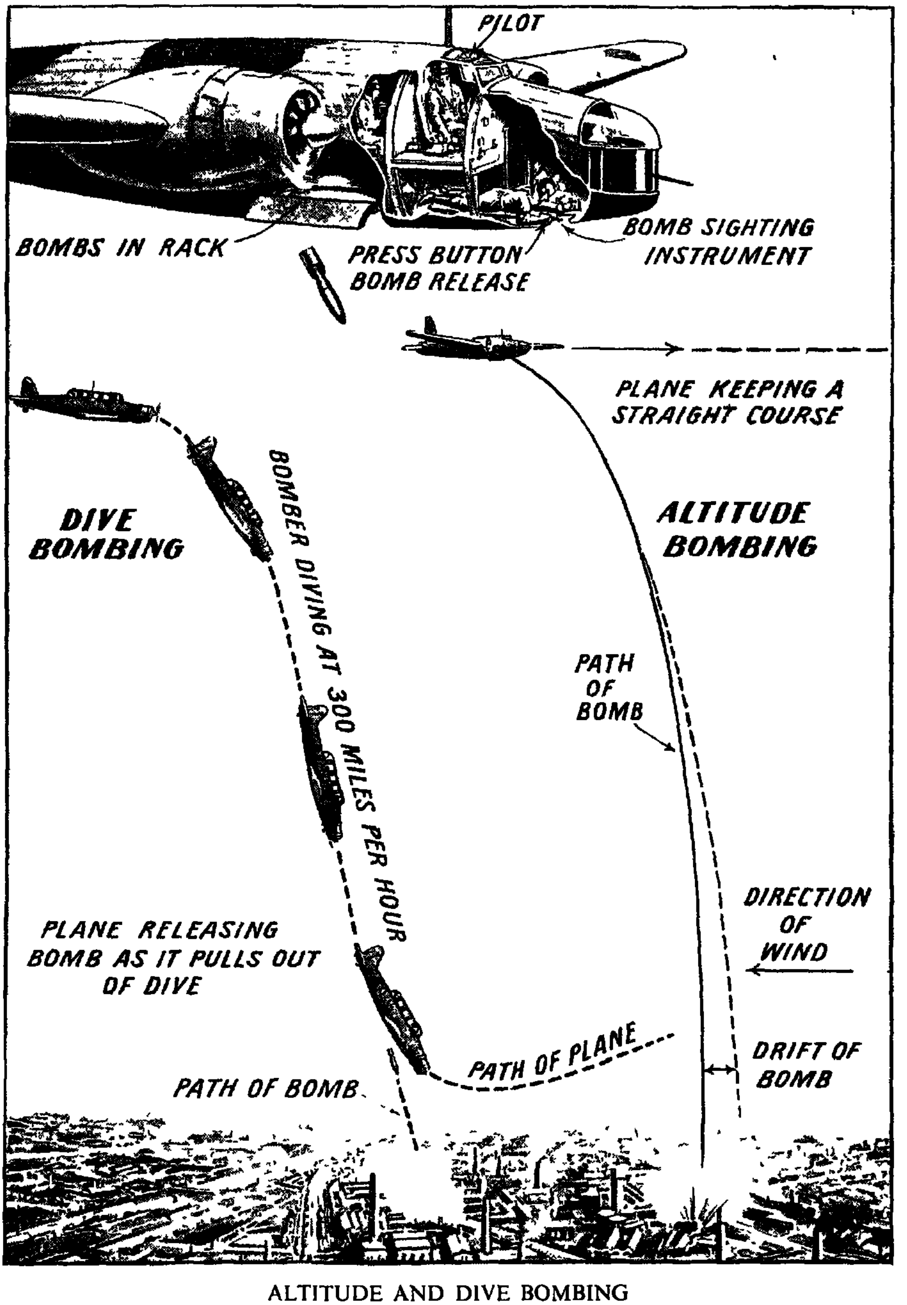
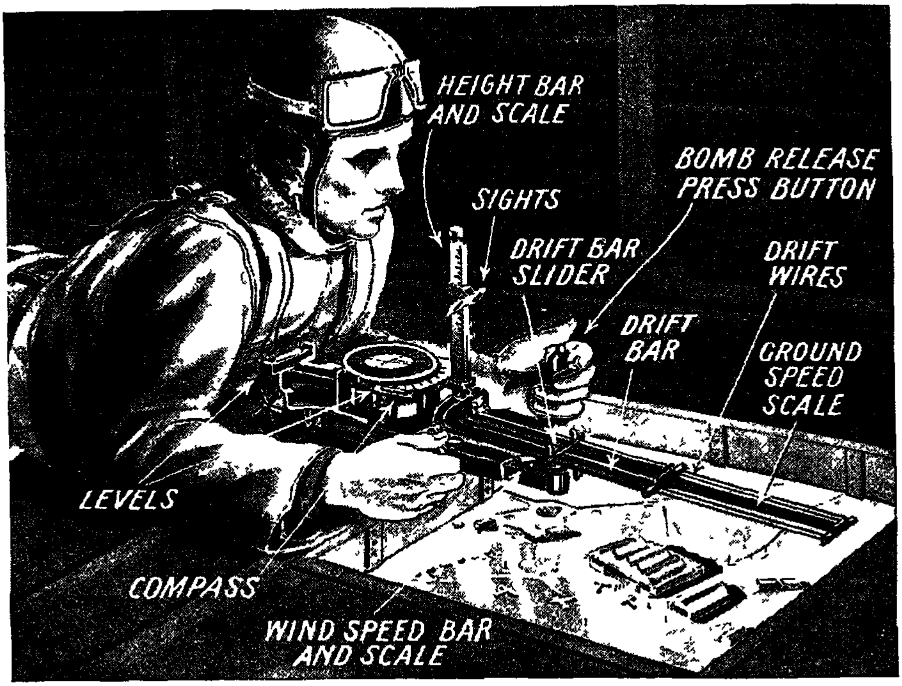


**Fig. 13.** *Pupils being instructed in the use of the wireless direction-finding loop aerial*




ALTITUDE AND DIVE BOMBING

**Fig. 14.** (*Top*) *Bomb sighter at work during altitude bombing* (*Below left*) *The path of an aeroplane during dive bombing* (*Below right*) *Drift of a bomb due to wind pressure.*




HOW AN OBSERVER AIMS HIS BOMBS

**Fig. 15.** *This complicated apparatus enables a bomb aimer to allow for the height and speed of his aeroplane and also for the drift of a bomb due to wind pressure*

as competent to carry out his duties after dark as in daylight.

To complete his training, the observer goes through a gunnery and bombing course. Dive bombing, already mentioned, is more the concern of the pilot than observer. Altitude bombing is, however, one of the most difficult of the observer's tasks

### ALTITUDE BOMBING

When bombs are dropped from a height of, say, 10,000 feet, they are not released when the aircraft is directly over the objective (Fig. 14). If they were, the speed of the aircraft would tend to carry them beyond the objective, and a strong wind might deflect them to one side of the other. Bomb sights must be adjusted to allow for the speed of the aircraft and for the wind (Fig. 15). The setting for drift caused by the wind must be calculated, and this is done from information already ascertained by observations made as the objective is approached Obviously, the greater the height from which the bombs are dropped the greater is the likelihood of error.

Preliminary practice in adjusting bomb sights is sometimes carried out in a darkened room with a bomb sight arranged above a large map, though there are now other methods. When the observer has acquired sufficient skill, he is taken into the air with a load of practice bombs to be dropped on a target. As each bomb falls, the observer marks the position on his chart. If it is off the target, he must work out corrections to be made to the bomb sights while the aircraft circles for the second bomb. These corrections must be worked out quickly and accur-

ately—indeed, quick and accurate work is required of an observer in almost all his duties The positions at which the bombs strike are also plotted by observers on the ground working with telescopic sights that take bearings from two points.

The observer's training is rounded off with a course in "fireworks," as Very light signals are often termed. Very cartridges are fired from a special pistol and are made in different colours to be used for signalling purposes. The Very lights are also used to ascertain the drift of the aircraft caused by the wind. This "fireworks" course includes the use of flame-floats for dropping on to water, and parachute flares for night reconnaissance.

The training of air gunners is similar to the gunnery training of pilots and observers, although they may receive more training since they are to specialize in the work. Wireless operators are also instructed in gunnery and also may be trained in bombing so that they may operate in a dual capacity when in the air Wireless operating and bomb aiming is a useful combination because, as already indicated, there is little likelihood of the wireless being in use when the aircraft is near its objective, so the wireless operator is free for other duties

**WIRELESS TRAINING IN AIRCRAFT**

The wireless operator is given a thorough ground training in the technical and maintenance side of wireless, and is thus equipped to make minor repairs to his apparatus when in the air, should this prove necessary Much of his training, however, is done while in the air Specially equipped aircraft are used for the purpose in which a number of operators may each work his own individual

LEARNING THE INTRICACIES OF BOMB SIGHTS

*Pupils receiving instruction in the intricacies of a bomb sighting apparatus By the aid of these complicated sights, bombs can be dropped with great accuracy*

A LESSON ON BOMBS AND THEIR USES

*A lecture on various types of aerial bombs in progress at a R A F training school All pilots and observers receive detailed instructions on aircraft armament*

set under flying conditions. Reception, transmission, direction finding, and the Morse code are all thoroughly covered in this training.

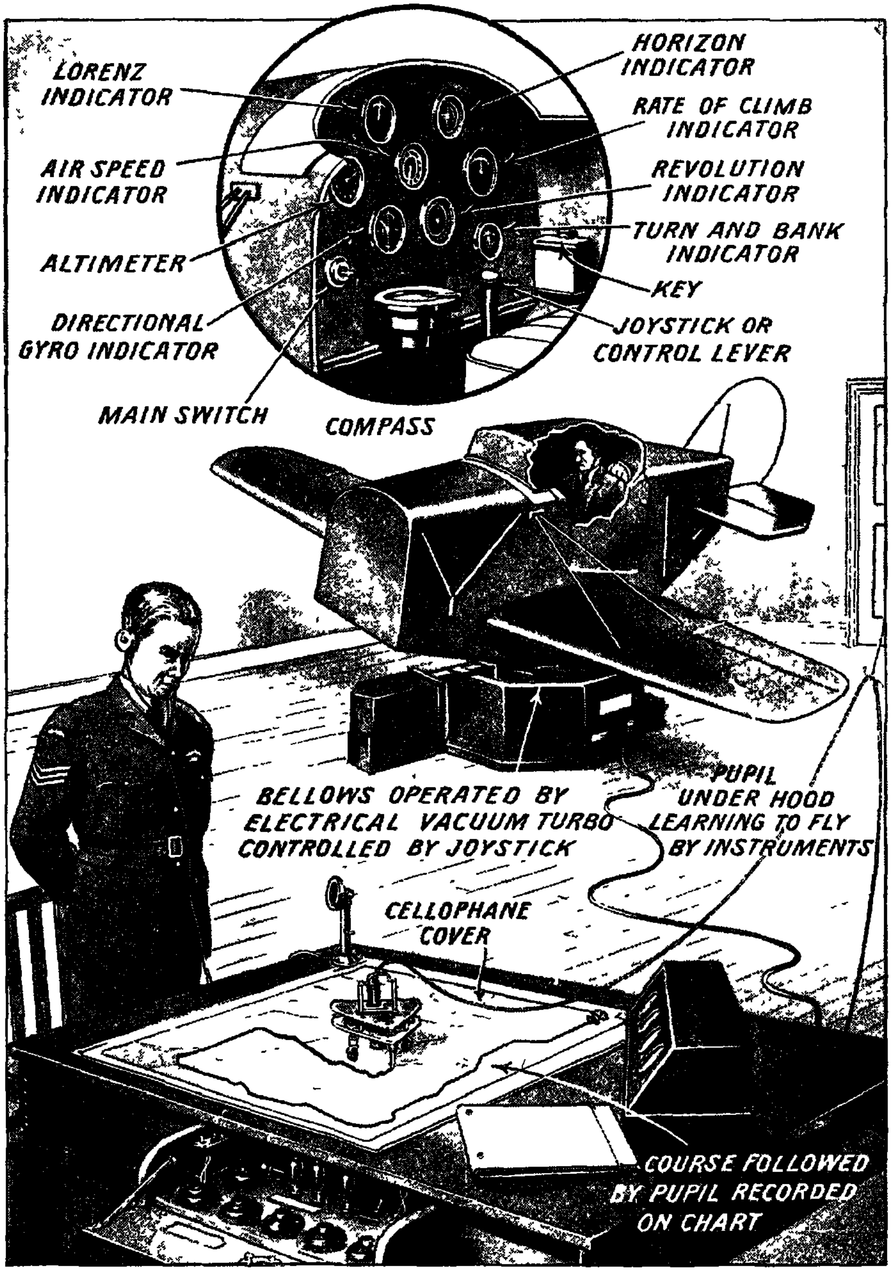
The specially designed flying classrooms of the wireless operators are but one of the instances of the elaborate equipment used for training

**THE LINK TRAINER**

The Link trainer is a device that allows blind flying to be taught and practised on the ground—inexpensively and without reference to weather conditions.

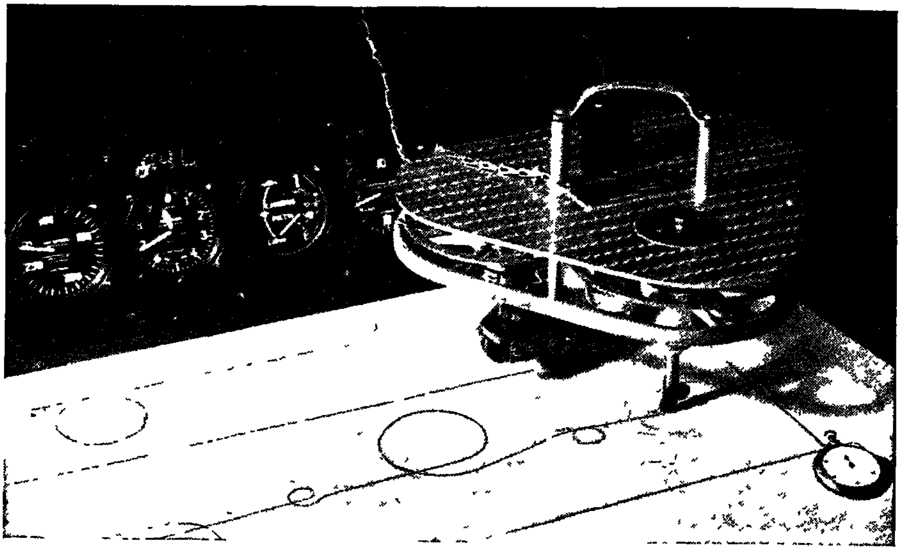
It actually consists of an enclosed cockpit with all the normal controls and instruments of an aeroplane (Fig. 16). The cockpit is so mounted that it reacts in the same way as an aeroplane to all movements of the flying controls. The clever part of the device is that all the instruments also react in a normal manner. For instance, if the control column is pulled too far back the speed indicated on the air speed indicator falls until the speed at which the aeroplane stalls is reached. Then, if the rudder is moved wrongly the instruments will indicate that the aircraft has gone into a spin. The pupil can be taught to extricate it by the appropriate operation of the controls.

At the control desk of the Link trainer sits the instructor, and before him is a chart. Over this chart an inker (seen in more detail in Fig. 17) driven by electric motors, moves in exact accordance with the course followed by the pupil inside the enclosed cockpit of the trainer If the pupil flies a triangular



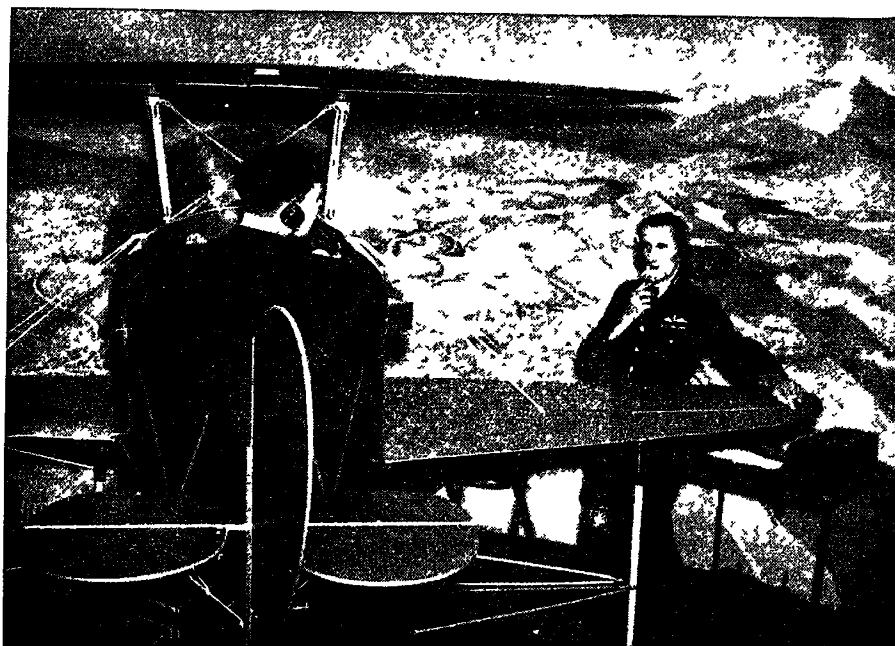

"FLYING" ON THE GROUND

**Fig. 16.** *Details of the working of the special Link trainer designed to give the pupil elementary training in flying while on the ground His exact course is recorded on a chart by a special instrument Inset shows the indicators on the instrument panel*



RECORDING A PILOT'S PROGRESS

**Fig. 17.** *The automatic inker or "crab," a most ingenious piece of mechanism which faithfully records on a chart the exact course "flown" by pilot in the Link trainer*



" RADIO SIGNALS " ON THE GROUND

**Fig. 18.** *The instructor can imitate the signals sent out by ground stations and the pupil in the Link trainer must follow these Notice the walls painted for realism*

HIS FIRST TRIP BY PARACHUTE

*This pupil, standing on a special platform, is learning how to jump with the parachute. He has pulled the ripcord of his parachute, which has opened In a moment he will be dragged off the wing of the machine and will float safely to the ground*


MEDICAL TESTS THAT ENSURE R A F FITNESS

(A) *A test for the heart and lungs After the lungs are filled to capacity the lips are applied to the mouthpiece of a mercury-filled tube The mercury has to be forced up by the breath to a level of forty millimetres, and kept there as long as possible Meantime the pulse rate is taken and if it rises sharply a weakness of heart and lungs is indicated* (B) *Nerve test Various arm and leg tendons are tapped with a rubber-covered hammer The reaction of the candidate enables the doctor to find any lack of nervous control* (D) *The rotation test is applied to ascertain a candidate's susceptibility to air sickness He sits with his head lowered while the chair is rotated ten times in twenty seconds in each direction His reactions are noted* (C) *Perfect eyesight is essential to the making of a good pilot This picture shows a candidate's eyes being examined through the electric ophthalmoscope. The ophthalmoscope enables the specialist to inspect the internal structure of the eye.*

course correctly, the inker traces out a triangle with the sides exactly in proportion to the distances flown on each bearing by the pupil. Should the pupil lose his way and "circle" while finding his correct position again, the circling will be traced out on the chart.

The instructor can speak to the pupil by means of a microphone, and can simulate a radio station in communication with the pilot. Even the signals sent out by radio systems for guiding pilots down at an aerodrome can be imitated by the instructor (Fig. 18).

### THE AIRMAN'S LIFEBELT

An airman, like a sailor, needs a lifebelt and for the airman the lifebelt is the parachute. Every member of an aircraft's crew has to carry a parachute with him on every flight and every airman is trained in parachute jumping Modern parachutes are very different from the clumsy and unreliable contrivances used by the Germans during the latter part of the war of 1914-18. Some further details of their uses and operation are given in Chapter V

### EXACTING MEDICAL TESTS

Because of the great strain involved in flying modern aircraft—especially under war conditions—the men who make up the crews of aircraft have to pass a very exacting medical examination. The strain is not only physical, it is also nervous and mental as well, and stringent tests ensure that the men who pass them will be able to continue to perform their duties efficiently under the most exacting conditions. The physical, mental and nervous fitness of R.A.F. personnel are always receiving the close attention of medical officers.

The British Empire has plenty of volunteers for flying work and with the well-tried and thorough systems of training outlined in this chapter is assured of an ample flow of efficient self-confident men to man her aircraft.

EMPIRE AIRMEN IN TRAINING

*The British Empire has plenty of volunteers for flying work Here are pupils of a R A F flying training school in Gloucester, where fighter and bomber pilots are trained*

TROOPS FROM THE SKIES

*Amongst the Army Co-operation work that may fall to the R A F. is that of dropping soldiers by parachute behind the enemy lines The Russian Air Force has practised this manœuvre extensively, but experiences in the Finnish War were not encouraging In this picture a multitude of parachute soldiers are seen dropping from troop-carrying planes.*

## CHAPTER IV

# ARMY CO-OPERATION

FOR purposes of description, the work done by the units of the R.A.F. co-operating with the Army may be divided into three categories—close co-operation, intermediate co-operation and distant co-operation. Generally speaking, the aircraft that carry out these three types of co-operation fall into three administrative classes

### TYPES OF CO-OPERATION

Close co-operation is carried out by the special Army Co-operation squadrons of the R.A.F. These, as explained in a previous chapter, are really the Army's own specialized aerial unit. Practically all their work is performed in close contact with men on the ground. In addition to these aircraft, which always remain under the command of the Army, certain fighter and bomber squadrons will be allotted to the Army commander and will carry out operations to his orders. It is these squadrons that carry out intermediate co-operation.

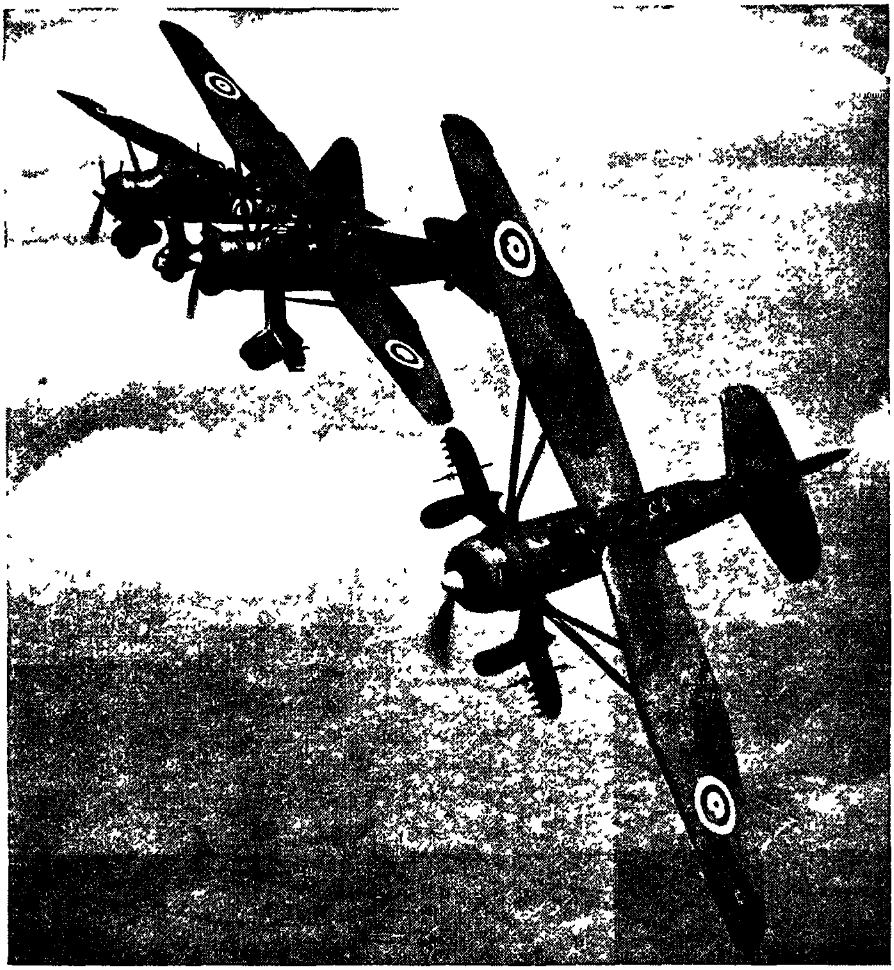
Distant co-operation is really part of the normal work of the R.A F. If the Supreme Command decide that the needs of the Army are paramount for the moment, a number of squadrons will be switched from their regular independent R.A.F. duties and ordered to aid the Army. If the Army is on the defensive, for example, they will be required to bomb enemy troop movements in all forward zones, and perhaps to launch machine gun attacks on advancing formations. If the Army is preparing an offensive these specially detailed squadrons may be called upon to assist by bombing forward trenches and defensive positions or by destroying the enemy's railheads and lines of communication. Such work is merely a specialized application of general aerial warfare and was dealt with in Chapter I. In this chapter we shall be concerned, in consequence, only with close and intermediate co-operation with the Army.

First we will consider close co-operation—the work of the Army Co-operation squadrons. Actually, many aspects of the work of these co-operating squadrons show up to the best advantage in a war of movement rather than one of position, such as obtains where strongly fortified lines face one another. However, there is still much useful work for close co-operation aircraft to carry out even in a war of position

The work requires some knowledge of Army manœuvres and tactics. This knowledge is gained by the pilots of the Army Co-operation aircraft in one of two ways. Some of the pilots are Army officers who have become pilots and whose previous Army training is invaluable to them in their flying duties. The others, who are R.A.F. pilots, gain their knowledge by long experience of co-operation with troops. While the Army Co-operation pilot needs to know the type of information of value to the Army, he does not have to interpret its significance. This interpretation is the duty of intelligence and staff officers to whom the pilot's information is passed on

### VARIETY OF DUTIES

The duties carried out by the Army Co-operation squadrons include reconnaissance, photography, spotting for guns, attacking troops, bombing, transport of staff personnel, message dropping and picking up, and dropping of supplies. In view of the multiplicity of



WINGS OF THE ARMY

**Fig. 1.** *Three Westland "Lysander" Army Co-operation aircraft on patrol Note the clean-cut lines and the uninterrupted vision the pilot has from his cabin Eight bombs are carried in the special racks on the stub wings fitted to the wheel casings They can be seen clearly in this picture. Despite its unconventional design, the "Lysander" is very fast*

these duties, it is not surprising that specially-designed aircraft with special equipment has proved necessary for the work.

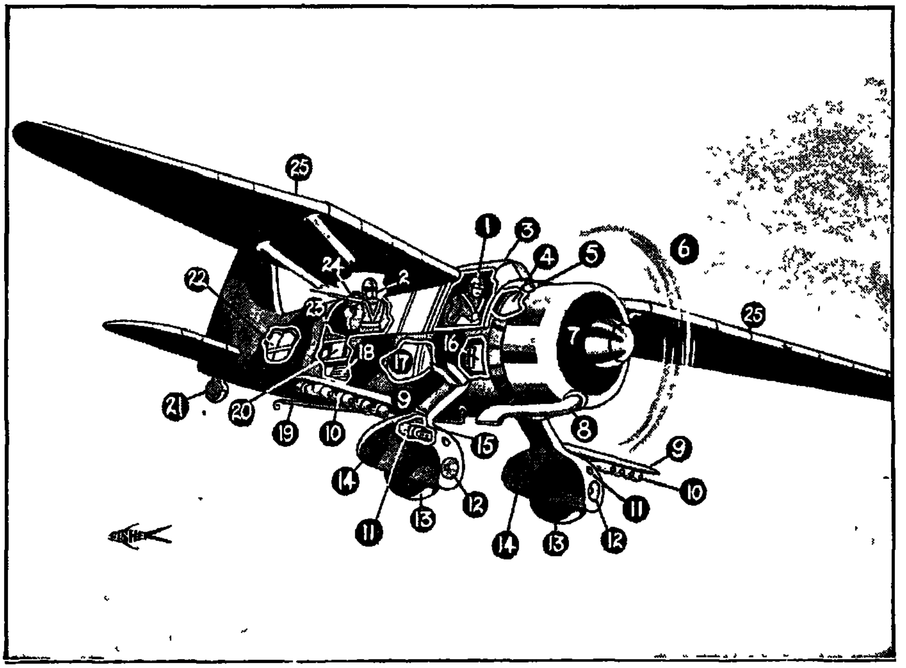
As in all fighting aircraft, the Army Co-operation machine must have a good turn of speed in order that it may escape from enemy aircraft when returning with information or photographs after a reconnaissance flight. Speed is also necessary in many of the other duties where a few minutes saved may bring important advantages, such as in the case of message carrying. In addition to a high top speed the aircraft must also have a low minimum speed. This is needed when picking up messages and when dropping supplies, and is frequently of the utmost

importance when landing and taking off. Army Co-operation aircraft often have to work from small fields or from runways hastily prepared by troops in difficult positions. Slow landing and take-off speeds are essential in such cases

## THE WESTLAND "LYSANDER"

The type of aircraft generally used for close co-operation, the Westland "Lysander" (Figs. 1 and 2), is undoubtedly the best aircraft of its type built. It is a high-wing monoplane with external bracing struts for the wings, and is powered by a Bristol radial engine. The aircraft carries two men in an enclosed cabin. The pilot, who also acts as observer, sits high in the cabin in the front, thus obtaining a good view downwards and forwards He is placed just in front of the leading edge of the wing, and his eyes are at approximately the level of the wing Thus, by a slight movement of his head, he can also obtain a good view backwards and sideways above or below the wing. The enclosed nature of the aircraft makes it a practicable machine for transport of officers of high rank.

The gunner, who also acts as photographer, bomber, and wireless operator, as circumstances require, is seated well behind the wing and has a movable gun firing to the rear. This gun is not the only means of defence provided in the




WESTLAND "LYSANDER" ARMY CO-OPERATION AIRCRAFT

**Fig. 2.** *Details of the construction of a Westland "Lysander" Army Co-operation aircraft 1, Pilot 2, Rear gunner 3, Sliding cowl 4, Oil tank 5, Controllable cooling gills 6, D H. Variable-pitch airscrew 7, Bristol "Mercury XII" 890-h p engine 8, Exhaust pipe 9, Detachable stub wings carrying bomb racks 10, Bombs 11, Machine gun 12, Harley landing lights 13, Internally-sprung wheels 14, Spats 15, Cartridge feed. 16, Engine oil cooler and cockpit heater 17, Petrol tank 18, Camera 19, Pick-up hooks 20, Radio 21, Tail wheel 22, Flares. 23, Ammunition 24, Machine gun 25, Slotted leading edges*

"Lysander," however, for the landing wheels have large streamline coverings, and in each of these fairings is a fixed machine gun firing forward and controlled by the pilot. Landing floodlights are also accommodated in the wheel fairings so that the aircraft may land in the dark without the assistance of any light from the ground.

The top speed of the "Lysander" is approximately 230 m.p.h., yet, with the aid of slots along the leading edges of the wing and flaps at the trailing edge, the aircraft can fly while fully under control at a speed as low as fifty-five miles per hour. The machine is fitted, on active service, with a transmitting and receiving radio and an electrically operated camera. Hinged panels in the floor of the fuselage give access to bombing gear and

VALUE OF THE AUTOGIRO

**Fig. 3.** *For observing enemy lines or positions, the autogiro is of special value It can take off in a few yards, can hover in a headwind and land almost vertically It can, of course, be armed and is in any event far less vulnerable to attack than a balloon*

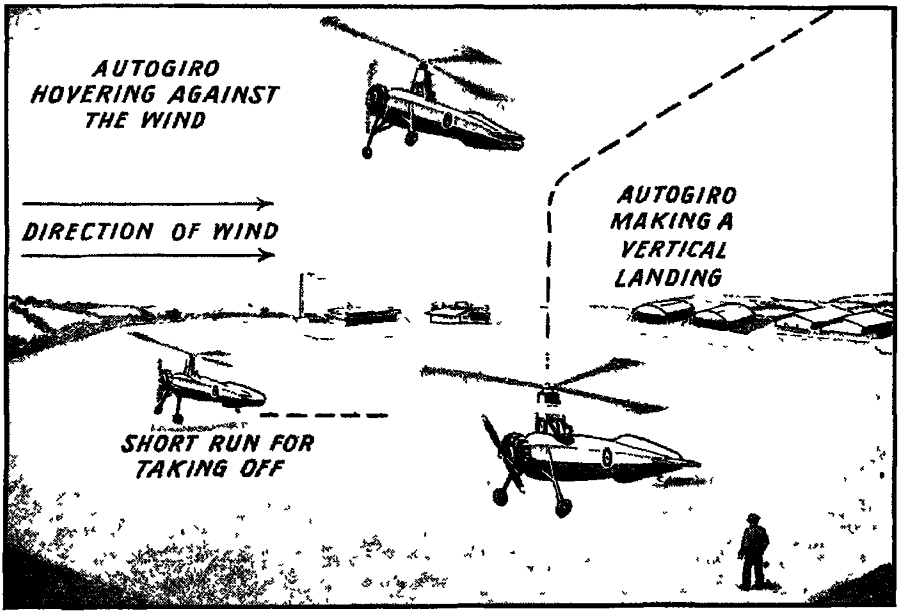



**Fig. 4.** *This diagram shows some of the advantages of the autogiro*

the apparatus for picking up messages.

Another type of aircraft used by Army Co-operation squadrons, the autogiro type of rotaplane, has narrow rotating wings instead of wings of normal design. Its chief advantages are that it can land without forward run, can take off in a few yards, and against a reasonable wind, can hover in the air (Figs 3 and 4) Although its top speed is not high, the autogiro is, in certain circumstances, obviously of special value. The latest types of this aircraft can also take off without any run by a form of "jump start."

The reconnaissance work of close co-operation aircraft requires them to keep an eye on developments in, and just behind enemy lines or positions—exceedingly dangerous work, because anti-aircraft fire from the ground is intense. Not only has anti-aircraft fire to be faced, but if the aircraft flies low to obtain detailed information, it is open to attack from machine gun fire and even rifle fire. There is also the ever-present danger of attack from enemy fighters. But the comparatively short distance of operations gives the pilot a chance to seek safety in his own lines if attacked by fighters.

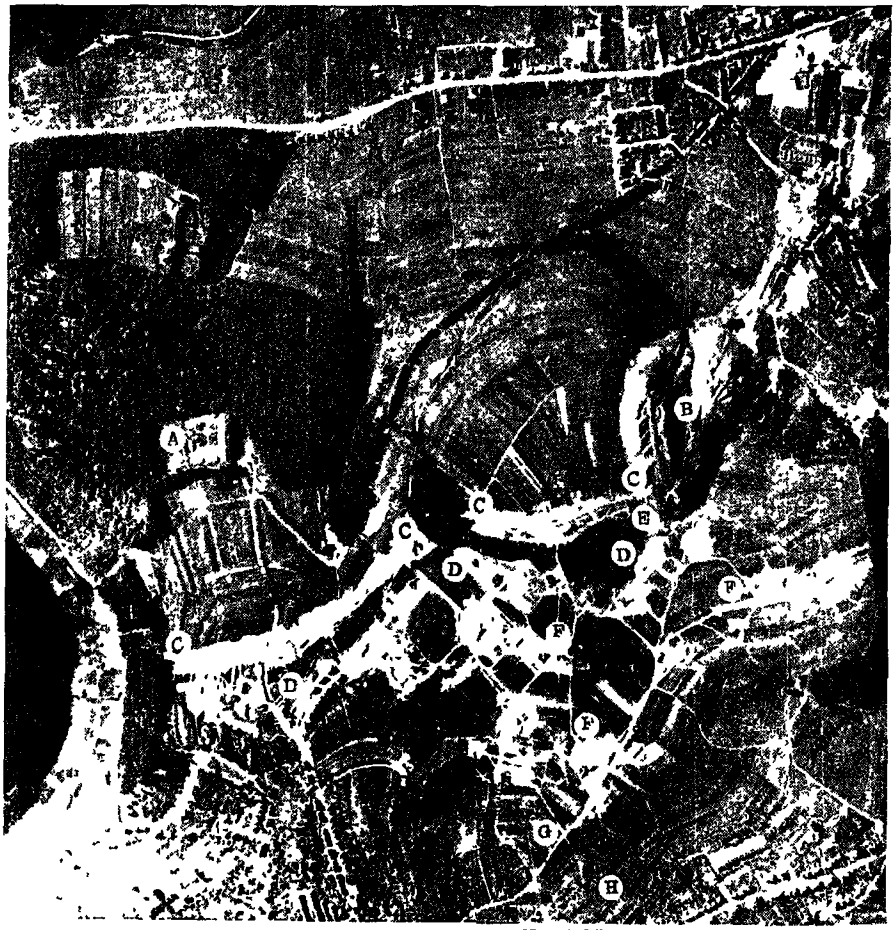
If most of the required information has been gathered, it is far better for a pilot to return with it than to risk being shot down in an aerial fight against greater odds. Sheer bravado has no value in warfare, and "courage with caution" is the watchword of the good fighter.

In some circumstances it is worth sending off any information gained by radio. Such a procedure normally would not be adopted, however, for the enemy is likely to overhear the transmission, and even if it is in code, to decode it. Information that the enemy knows has been discovered is seldom of value. He can always change his plans—with the result that the information becomes valueless.

Whenever possible, reconnaissance work is backed up by the taking of

photographs. These can be studied at leisure, and may reveal information that passes unspotted by personal observation. Also, the superior knowledge possessed by the intelligence officer of a campaign in general may give significance to some detail that might appear unimportant to the less well-informed pilot of the aircraft.

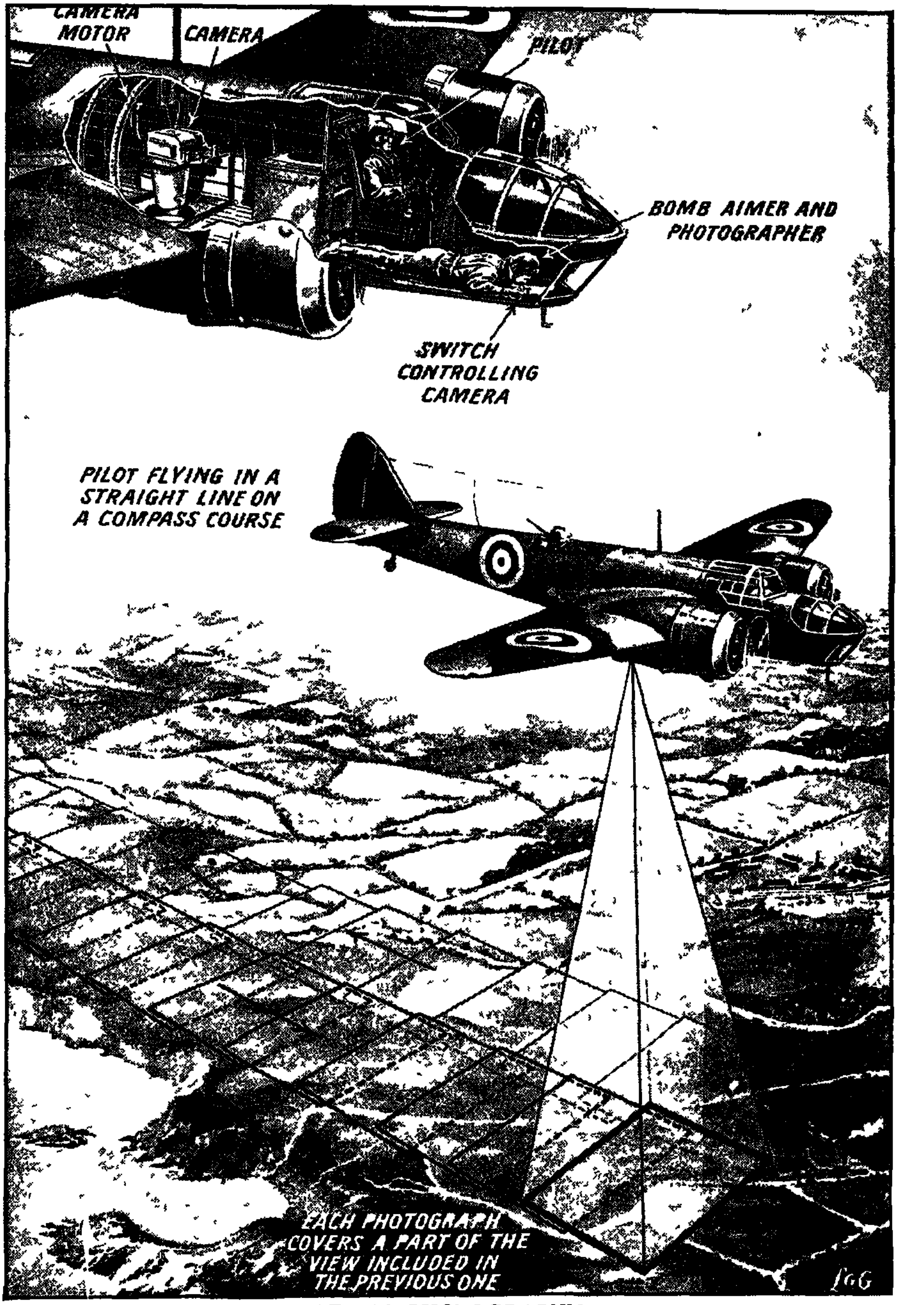
Photographs fall into two principal classes—oblique and vertical. Vertical, or plan photographs, are the more usual, but oblique photographs, especially when taken at low altitudes, will show details that are invisible in plan photographs. Plan photographs may be taken at great or at low altitudes according to whether information of a general nature or detailed information is wanted. Advances in aerial survey work since the war of 1914-18 have been tremendous. The highly scientific methods used in civilian





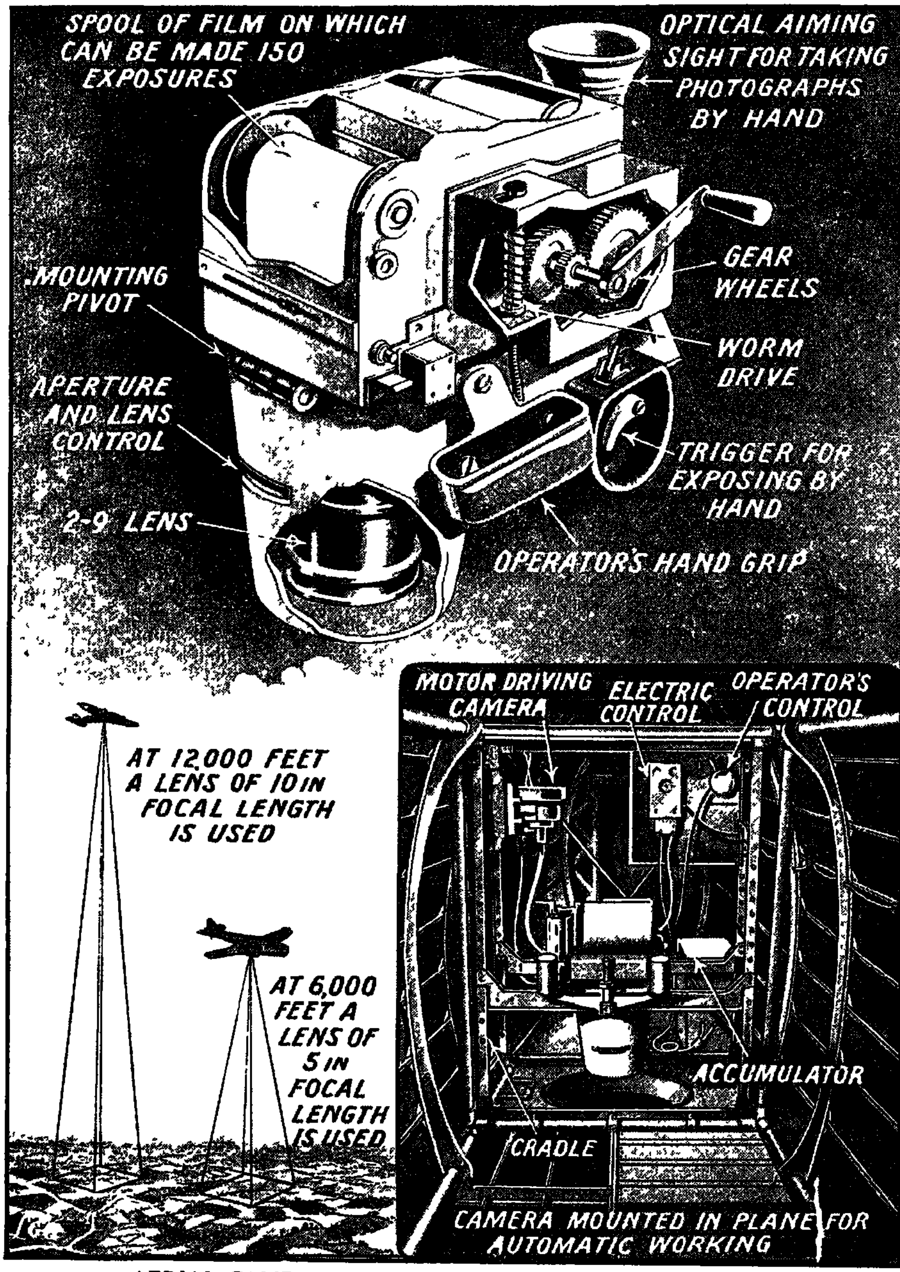
SIEGFRIED LINE FROM THE AIR

*Photograph of Siegfried Line fortifications near Saarbrucken taken by R A F on reconnaissance* (A) *Barracks* (B) *Slag heap* (C to C) *Anti-tank obstacles* (D to D) *Wire* (E) *Turning point* (F) *Blockhouses under construction* (G) *Light railway* (H) *Tree plantation*




AERIAL PHOTOGRAPHY

**Fig. 5.** *In the top part of the picture the photographer is shown controlling the automatic camera The bottom part of the picture shows how the photographs all overlap*




AERIAL CAMERAS—HOW THEY ARE FITTED AND USED

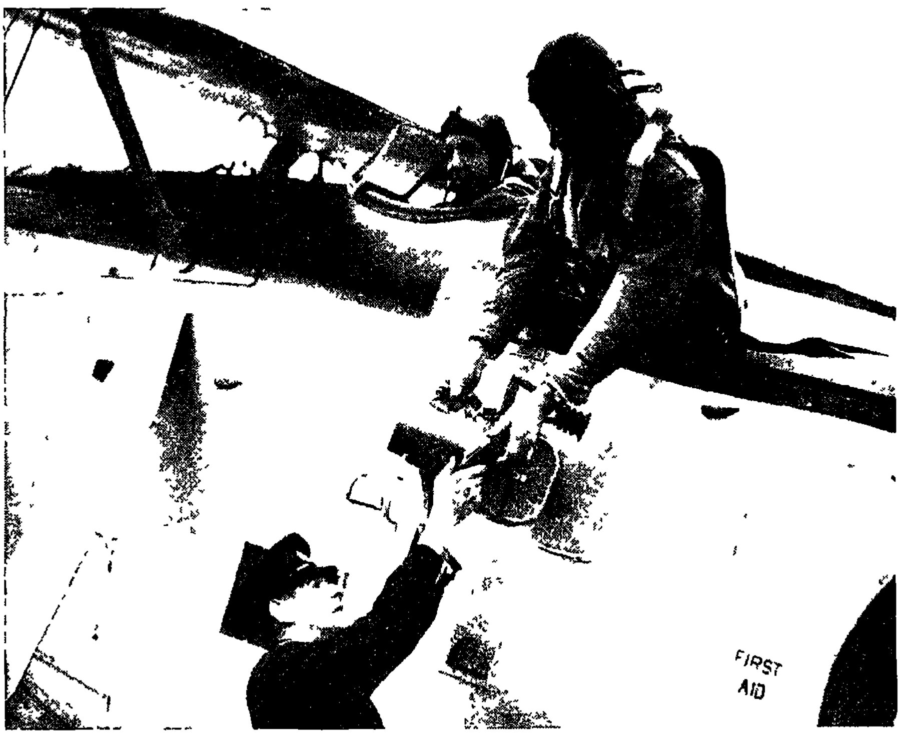
**Fig. 6.** (*Top*) *Details of a hand camera* (*Below right*) *Automatic camera in position* (*Below left*) *All photographs must be of uniform size, and to ensure this uniformity the focal length of the lens used is varied with the height of the plane*

surveying of uncharted tracks of country have been adapted for aerial warfare By these methods it was possible to obtain a photographic map of the whole of the Siegfried Line even in the early stages of the war.

The method of obtaining photographic maps is to make one exposure after another as the aircraft flies over a given strip of country. At the end of the strip the aircraft turns and flies back in the opposite direction, but at a predetermined distance from the side of the strip already covered (Fig. 5) Further photographs are taken and the procedure is continued until the whole of the desired area has been photographed If the maps obtained from the photographs are to be accurately to scale, the aircraft must maintain a straight course, be kept on an even keel, and fly constantly at the same height Enemy gunfire must be ignored, and attendant fighters must be present to ward off attacks by enemy aircraft. The difficulties of satisfying all these requirements in conditions of war would seem almost insuperable, but despite such difficulties valuable photographic maps of large areas are readily obtained.

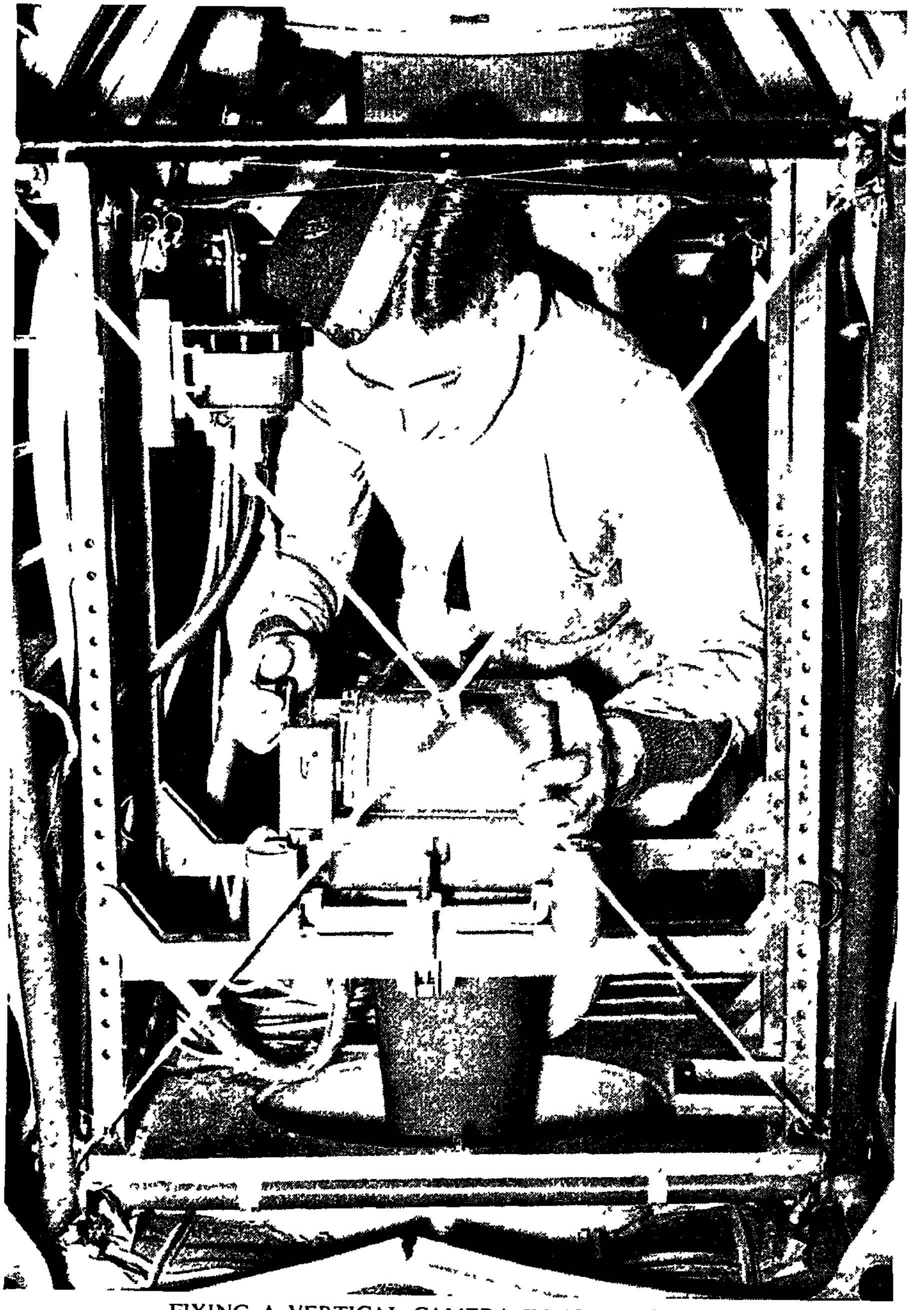
### CORRECTING INACCURACIES

Corrections for unavoidable inaccurate flying can be made to a certain degree in the printing of the photographs. Instruments showing height, speed, level and so forth, are placed in a position in the aeroplane where they are photographed on the side of the film when each exposure is made. With this record before him the photographer who prints




OFF TO PHOTOGRAPH KEY OBJECTIVES

*The camera is handed in to the observer prior to a photographic reconnaissance flight*



FIXING A VERTICAL CAMERA IN AN AIRCRAFT

**Fig. 7.** *How the aerial camera is fixed in position in the fuselage of the aircraft. The electric motor which operates the camera can be seen at the top left*

the photographs can make minor adjustments. The photographs are also arranged to overlap considerably on the line of flight, and to a smaller extent at the sides of the strips. Thus, every inch of the area can be photographed at least twice, so that one photograph becomes a check on the next, as seen in Fig. 5.

The electrically controlled camera can be set according to the speed of the aircraft and the amount of overlap required on each picture. It will make exposures automatically at the correct instant and will wind the film between each exposure, thus leaving the gunner free to keep a watch for enemy aircraft.

By taking two photographs of the same area from different angles, it becomes possible to view the pictures stereoscopically. The two photographs are placed side by side and viewed through an optical system that makes them appear as one on which the contours of the ground and other varying levels stand out Often, camouflaged buildings can be spotted in this way when they might not be apparent in a non-stereoscopic view.

### USING A HAND CAMERA

Each aircraft carries two cameras, both compact and virtually foolproof. These cameras are designed to work under the most unfavourable circumstances and require very little attention. One is completely automatic and contains a magazine large enough to give 125 exposures, and is capable of being reloaded in the air in a few seconds The other camera is held in the hands and pointed in the desired direction precisely as in ordinary photography (Fig. 6).

Let us see what happens on a typical reconnaissance flight. At the start of the flight the vertical camera is fixed into place (Fig. 7) and the oblique camera is placed ready in the fuselage. The vertical camera is set before the flight begins, according to the probable visibility and flying altitude. Then the aircraft takes off on a flight that, for example, has as its purpose the collection of information about certain enemy aerodromes. On approaching the first objective the pilot takes the aircraft down through the cloud bank, sees on the left a circle of hangars, and swings his aircraft round towards it. A straight and level course, which is necessary for good aerial photographs, is set over the middle of the aerodrome. The camera is started and after photographing enemy aircraft lined up 2,000 feet below, the pilot goes on to his next objective. A typical picture of a German aerodrome secured in this way is seen in Fig. 8.

*[British Official Photograph Crown copyright reserved*

HAND CAMERA

*An observer taking oblique photographs with a hand-type aerial camera*

Suddenly the pilot turns the aircraft off its pre-arranged course and signals to the observer to start the vertical camera, for he has spotted a substitute landing ground.

At their farthest point the observer prepares to photograph another aerodrome and the aircraft flies on at a fixed speed, height and course Now, perhaps,

the enemy fighters come on the scene. Three Messerschmitts are flying to meet the reconnaissance aircraft. Most of the necessary photographs have been taken, however, before the enemy fighters have had time to get into position from which they can attack The gunners hold their fire until the enemy machines are close, and in the meantime the aircraft keeps on its course until the camera has finished its task. Only then does the aircraft slip upwards into the clouds. It may continue on its way to get final photographs of another aerodrome. It may be necessary to drop to 1,000 feet to ensure good results, and the observer now uses the oblique camera. Pom-poms and machine guns fire at the intruder, but it is off again before any damage can be done.

On return to the base, the magazines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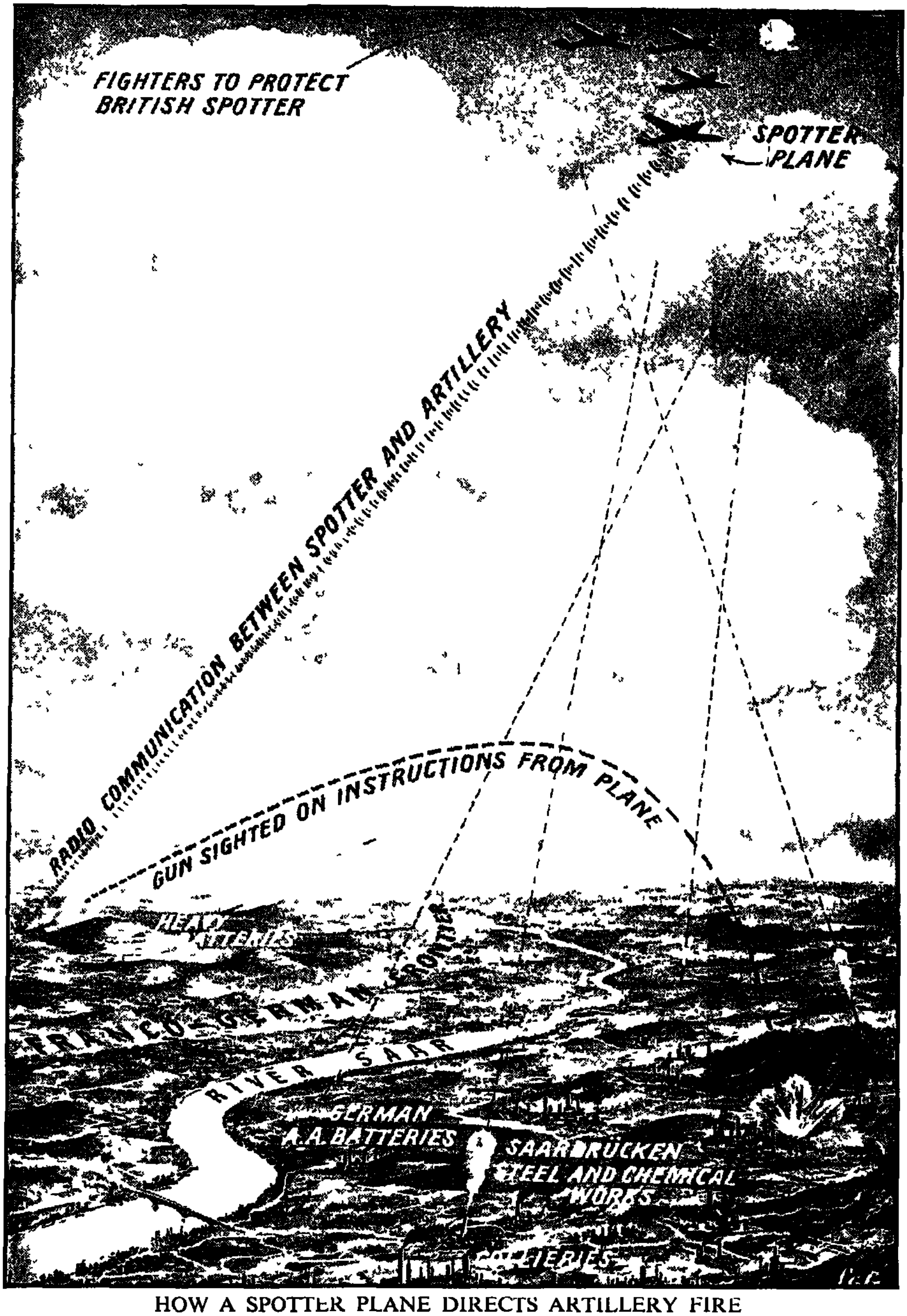
PILOT'S VIEW OF A GERMAN AERODROME

**Fig. 8.** *Photograph of Gutersloh Aerodrome, east of Munster in Germany, taken by the R A F on reconnaissance The key is* (A) *Refuelling point* (B) *Small sheltered trenches* (C) *Compass swinging base with an aircraft on it* (D) *Aircraft dispersed round aerodrome* (E) *Ammunition store* (F) *Some form of stacked crop* (G) *Hangars* (H) *Aircraft on ground.* (I) *Repair hangar* (J) *Special railway for servicing aerodrome.* (K) *Railway station* (L) *Shelter trenches near barracks* (M) *Motor transport* (N) *Tree-lined road* (O) *Quarters.*




HOW A SPOTTER PLANE DIRECTS ARTILLERY FIRE

**Fig. 9.** *The observer's directions are transmitted by radio The fighter planes protecting the spotter actually fly considerably higher than it is possible to show in this diagram*

are removed trom the camera, and films developed and printed (*see* Chapter V). Meantime the observer makes his report, and in two or three hours the prints are being inspected by experts. Stereoscope and magnifiers tell them much that was unseen by the trained observers in the aircraft—for example, types of aircraft will be recognized and activity in the lines of communication noted.

Such in brief is a typical instance of R.A.F. activity in this connexion Sometimes it is less straightforward, and photographs may have to be taken from as low as 500 feet or as high as 24,000.

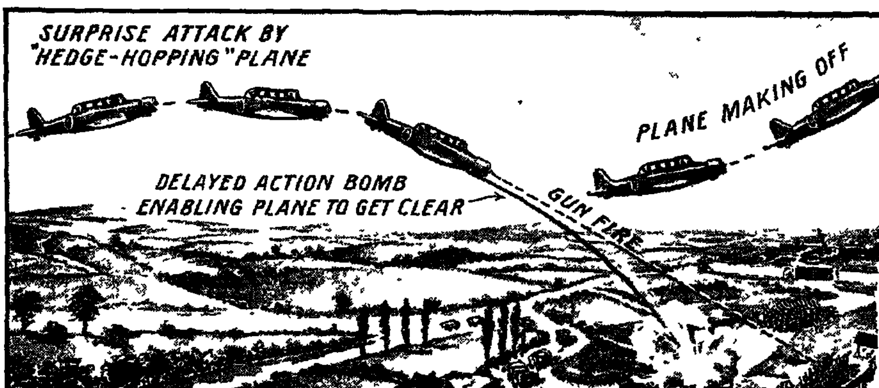
### "SPOTTING" FOR THE GUNS

One of the most important duties carried out by close co-operation squadrons is "spotting" for the guns. The spotter aircraft is equally valuable to long-range fixed guns and to batteries of field guns If the objective is a moving one—such as a convoy of lorries—or if time is important, the services of spotter aircraft are essential

The spotter aircraft cruises backwards and forwards above the objective, and maintains contact with the battery by means of radio (Fig 9). The observer in the aircraft is able to note where the shell are bursting and to send any necessar corrections to the gunners by means his radio. Perhaps the first shells f short of the objective, so the observer i the aircraft tells the gunners to increase the range a little. The next shells may fall beyond the objective. Then, by telling the gunners to fire at an intermediate range, the observer is soon able to report "objective destroyed."

Of course, the spotter aeroplane car not expect to be allowed to carry on n duties unmolested. As soon as the enemy realize that the spotter aircraft is operating, fighters will be sent up. That is why the close co-operation aircraft must be able to give a good account of itself in a fight. As with photographic operations however, a number of fighters may b sent with a spotter aircraft to guard against enemy fighters so that it m carry on its work.

Another duty of close co-operation aircraft is what is known as ground strafing or trench strafing. This is unpleasant and dangerous work, but it is a valuable method of breaking up an attack that ha




"HEDGE-HOPPING" TO SURPRISE THE ENEMY

**Fig. 10.** *An attack by low-flying aircraft is called "hedge-hopping." It has the advant of surprise and can demoralize enemy troops On the other hand, the attacking mach is exposed to rifle fire and is flying too low to be able to recover from any unexpec swerve or dive "Hedge-hopping" is therefore highly dangerous work.*

GROUND STRAFING IN PROSPECT

*Three "Lysander" aircraft diving through the clouds to make a bombing and machine gun attack on an enemy position These machines are well adapted for ground strafing*

ecome serious. The aircraft flies low over troops who may be in trenches, manning guns, or advancing. As the aircraft skims a few feet above their heads the pilot sweeps them with machine gun bullets (Fig. 10). It is a terrifying method of attack from the point of view of the troops, and its value is probably as much n the demoralizing effect produced as in he actual number of casualties inflicted it is dangerous work to the pilot because is machine is at the mercy of ordinary ifle fire, and a single lucky hit may ring him down. His nearness to the ground leaves him no height to recover rom a swerve or dive that may be caused y slight damage to his machine

### GROUND STRAFING

Similar tactics are employed against treating troops with the aim of turning retreat into a rout. In such circumances the aircraft can largely be condered as taking the place of the cavalry sed in less modern warfare. This type of attack is likely to prove expensive in machines and personnel, but in certain circumstances the value of the attack justifies the means

In a war of movement, it is quite common for a small section of men to become isolated and to lose contact with their comrades They may even be surrounded by the enemy and not know in which direction their own troops lie. In these circumstances it would be unwise for them to move because they might go straight towards the enemy. Should they have a radio transmitter and receiver with them, they would be able to ascertain the true position and to make plans accordingly, or they might simply be advised to dig themselves in until relief came. Without radio their position would be almost hopeless if it were not for the Army Co-operation aircraft. Should there be sufficient space for the aircraft to land after it had spotted the besieged troops, it would be easy to maintain contact with them. But even if

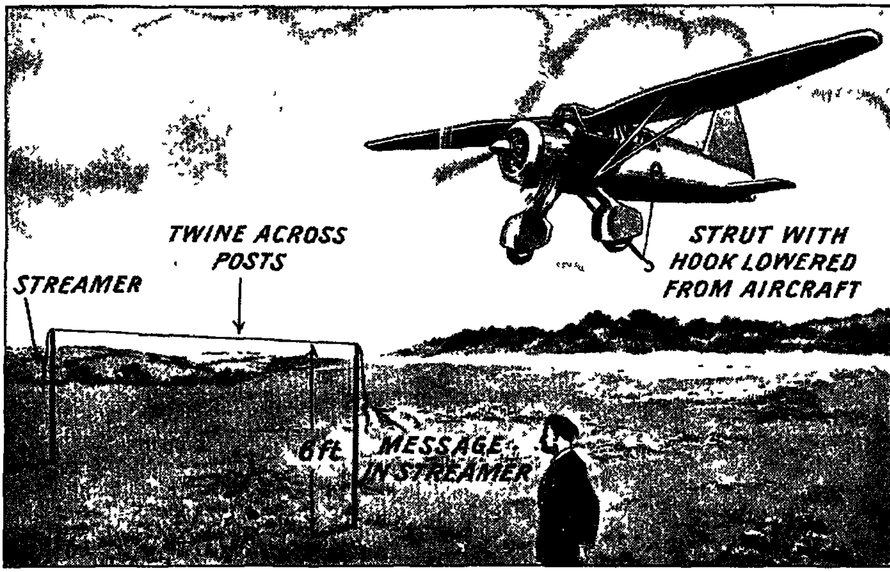



**Fig. 11.** *Pilot picking up an urgent message without landing Valuable time is thus saved*

it cannot land, the aircraft is still able to maintain contact by means of messages. Dropping a message from the aircraft to the troops on the ground presents no difficulties, but to pick up a message from the ground without alighting requires special, but simple, apparatus.

### PICKING UP MESSAGES

The method used is illustrated in Fig. 11, and is as follows The message is placed in a streamer tied to one end of a piece of twine about ten feet in length, to the end of which is attached another streamer, or small weight. The line is then laid across upright sticks about six feet in height in such a way that it can be pulled free easily. Arranged beneath the aircraft is a long thin strut, attached to the fuselage by a hinge and having a hook at its lower end. This strut is lowered beneath the aeroplane when it flies just above the line stretched between the posts on the ground. The strut hits the twine, and the twine slides to the end of the strut there to be caught in the hook The streamers on the end of the twine preventing it from slipping through the hook. The aircraft now climbs, the strut is raised, and the message removed.

Bombing carried out by Army Co-operation aircraft is, in a way, an extension of ground strafing duties The bombs are usually small ones and are frequently dropped from fairly low altitudes. Altitude bombing may also be carried out, however, and bomb sights are therefore provided in the floor of the aircraft. Bombing attacks would be carried out on objectives such as field batteries that were causing particular damage, or on the advanced operations posts and machine gun nests.

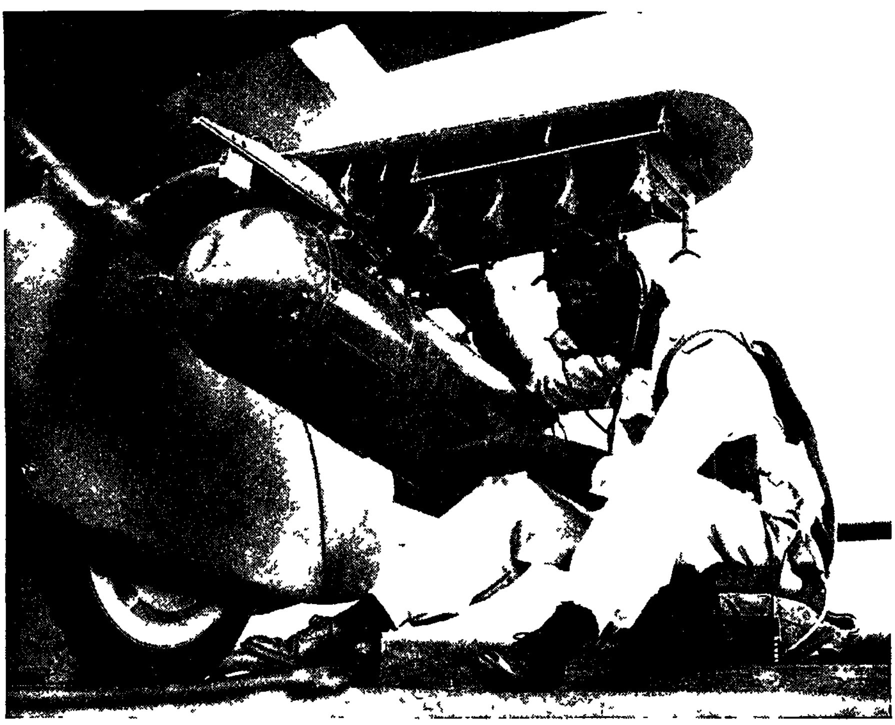
Army Co-operation aircraft are increasingly used for the transport of staff or other important officers between, say, front line positions and staff headquarters in the rear. This transport duty has been to some degree responsible for the development of enclosed aircraft for this co-operation work. Before the introduction of the Westland "Lysander" two-

seater open aircraft were largely used.

Finally, close co-operation duties may involve the question of dropping supplies. The circumstances in which this could be required might be similar to those already described in which a body of troops had become isolated. Special racks can be attached to the wheel fairings of the "Lysander" to accommodate containers (Fig. 12). Food, ammunition, or other supplies dropped in plain containers would suffer considerable damage on impact with the ground. Special containers, the principles of which are illustrated in Fig. 13, are therefore used. A small parachute opens when the container is released and this reduces the rate of descent to a reasonable speed Further, to protect the supplies, the container is fitted with a false nose. This nose is of such a strength that it will collapse under a hard blow and so absorb the shock that would otherwise be transmitted to the supplies. So successful is this arrangement that even eggs have been successfully dropped in this way.

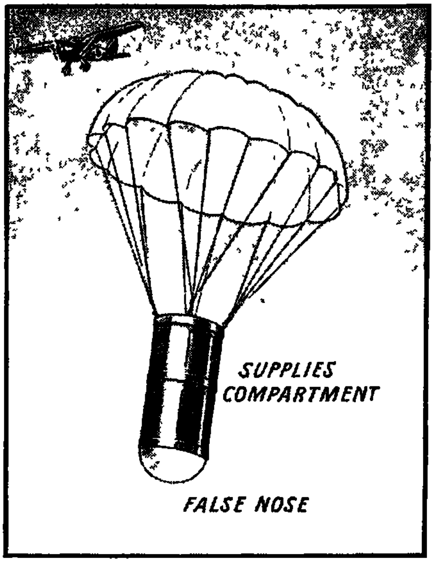
## TROOP CARRIERS

A specialized form of Army co-operation, developed since the war of 1914-18, is that of carrying troops by aircraft. This has proved extremely valuable in countries like India and Palestine during peace time, and has immense possibilities in a full-scale war. It is obviously of use in dealing with guerrilla tactics in country where the terrain makes the rapid transport by land of even small numbers



FOOD CONTAINER BEING LOADED ON TO A "LYSANDER"

**Fig. 12.** *Metal containers like this can be used to drop food or ammunition. The false nose, which absorbs the shock when the container strikes the ground, can be seen*

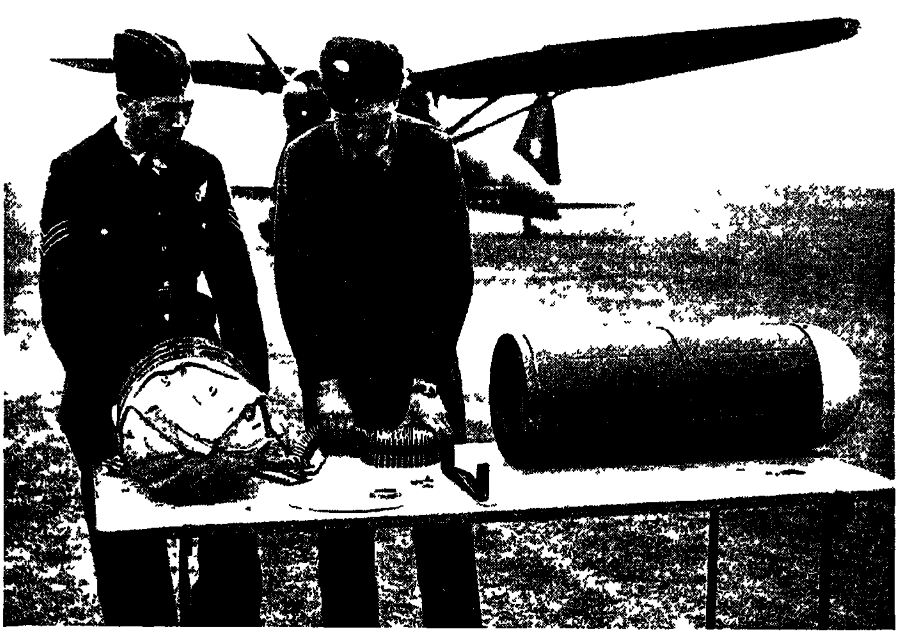



SUPPLIES FROM THE AIR
**Fig. 13.** *A food container after its release from an aircraft A false nose takes the bump*

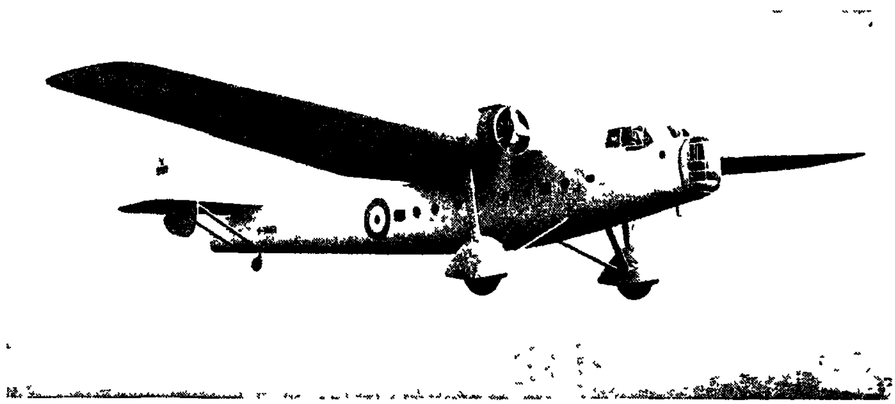
of troops quite an impossible project.

For carrying troops, large twin-engined aircraft are used, each capable of transporting some twenty troops with full equipment. The principal aircraft specially designed for this work is the Bristol "Bombay" (Fig. 14). Although primarily designed as a troop carrier, the "Bombay" could also be used as a heavy bomber, as an ambulance aircraft for the carrying of wounded, or as a freighter to transport large quantities of ammunition or equipment. The "Bombay" is a high-wing monoplane with two 1,000-h.p. engines and can give a good account of itself if attacked since it has enclosed gun turrets in both the nose and the tail.

Yet another aspect of troop carrying deserves our consideration. It is the method, largely developed by Russia but experimented with by France, and Germany, of dropping troops by parachutes



LOADING A CONTAINER WITH AMMUNITION
*The container is not always used for carrying food Here one of them is being loaded with ammunition By this means supplies can be dropped to troops surrounded by the enemy.*



TYPICAL BRITISH TROOP CARRIER

**Fig. 14.** *The Bristol "Bombay" was designed as a troop carrier, but can be used as a bomber It has gun turrets in both nose and tail, and bomb racks can be fitted*

from troop carriers. The object of such a manœuvre is to drop troops, together with machine guns and other equipment, behind the enemy lines so that they may begin an attack from the rear. To be successful, such an operation would require to be carried out on a large scale, involving the dropping of a large number of men. Perhaps a few only might be dropped with the idea of capturing an aerodrome and making it available for further troop carriers to land with other troops. In a war in which the enemy air force was weak, or had been for the greater part destroyed, the scheme might prove successful. Otherwise it is unlikely that the large number of machines required for the operation would be unmolested by enemy aircraft. Even if the troop carriers succeeded in releasing the men with their parachutes, the men would undoubtedly be fired on while floating defencelessly to the ground. Immediate attack on the survivors would prevent the parachutists from becoming organized when they reached the ground

In a war in which strong opposing air forces were engaged, the troops carriers, if used as bombers, would be able to do far more effective damage than the few troops they could successfully and secretly drop behind the enemy lines.

A significant commentary on the dropping of troops by parachute was provided by an incident early in December, 1939, in the war between Russia and Finland A large-scale attempt to land troops in this way on the Karelian Isthmus failed completely. Many of the parachutists were shot dead in the air and before the remainder could assemble their machine guns they were attacked and captured by Finnish troops. Germany had better success with the same method in Poland, however, but Polish resistance was already disorganized. It would seem that parachute troops are only of value against an already demoralized enemy.

### HOW AIRCRAFT REPLACE GUNS

From one point of view, the bombers that carry out intermediate co-operation with the army may be considered simply as long-range guns Their object is to destroy objectives in the militarized area immediately behind the enemy lines. This area may extend a long way behind the lines, and the bombers will often operate at distances well outside the range of the biggest guns. Even if the

work could be carried out by long-range guns, aircraft are frequently more effective and speedy in hitting an objective.

The numerous objectives behind the lines that are worthy of the attention of bombers will have been spied out and their positions marked by reconnaissance aircraft of the intermediate co-operation squadrons. Ammunition dumps, railway junctions, trunk roads, and aerodromes are examples of such objectives.

### OBJECTIVES OF BOMBERS

With the modern development of mechanization, and the large use of tanks, transport lorries and other vehicles, trunk roads can be as valuable as railway lines. The destruction of a section of a main road may delay reinforcements and supplies as much as damage to a railway track. In modern warfare the troops behind the lines are in as much danger as those in the front lines—indeed, in some instances, in even greater danger.

The appearance of enemy aircraft behind the lines, even when no attack takes place, can cause delay and disorganization to convoys. On the appearance of enemy aircraft the vehicles must be driven to the side of roads to hide them as much as possible and allow the men to take cover. If this has to be done frequently, the time taken by a convoy to reach its destination is considerably increased.

Regular reconnaissance flights behind the enemy lines are a part of intermediate co-operation work, and are carried out continuously except when weather conditions make flying impossible. Similarly, regular patrols are carried out by intermediate co-operation fighter aircraft.

INFANTRYMEN AND EQUIPMENT IN A TROOP CARRIER

*Men and equipment being transported in a Bristol "Bombay" troop carrier This operation is of special value in guerrilla warfare in country which normal transport cannot penetrate*

The object of these is to find enemy aircraft whether they are on reconnaissance, spotter, bombing, or other operations. Naturally, if enemy aircraft can be spotted when or before they reach the lines there is more chance of stopping them before they can obtain much information or do much damage.

When their locations are known, aerodromes come in for much attention from the opposing air forces. That is why camouflaging and the hiding of aircraft on the ground is of such great importance (*see* Chapter V). A bombing attack on an aerodrome, even if it only succeeds in blowing a number of craters in the surface, may keep many enemy aircraft on the ground while the runways are repaired. None the less, the vulnerability of aerodromes to attack is partly compensated for by the speed and range of modern aircraft. The aerodromes can be situated farther behind the lines. Thus enemy aircraft have to traverse more country before reaching the aerodromes and are more likely to be attacked successfully on their way.

### AIRCRAFT'S PART IN ATTACK

Let us conclude this chapter with a sketch of how the aircraft play their part throughout any phase of an army attack. Before an attack is launched in any sector every endeavour will be made to obtain superiority in the air—at least in that sector. This is most important In the war of 1914-18 it was found that air superiority played a big part in maintaining the fighting morale of the troops Superiority in the air might be gained by a larger force, or by better aircraft, or by more skilled pilots. Superiority in numbers could be achieved at least temporarily by a skilful drawing away of enemy aircraft to an operation in another sector of the line. Better aircraft and more skilled pilots is the aim both of the aircraft industry at home and the training command. The question of numbers of aircraft is one based on the fundamental principle of waging any successful war—to concentrate the right forces on the right point at the right time.

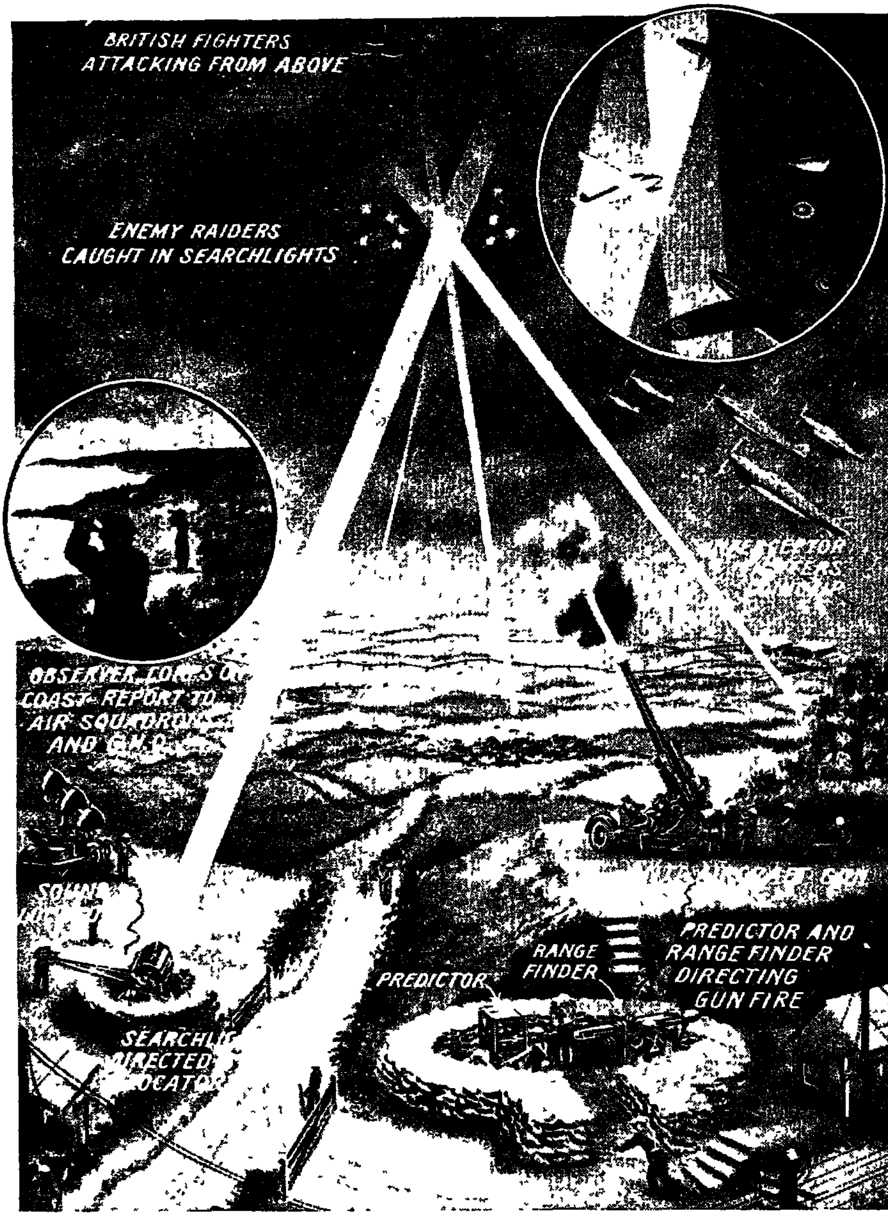
If superiority in the air is not achieved before an advance, then the attempts of an air force to assist an army will be largely nullified by the opposing air force. Let us suppose that superiority has been won.

### PHASES OF ATTACK

Reconnaissance aircraft will be used to gather information about enemy positions and troop movements while plans are being made and forces concentrated for the attack. This reconnaissance will be carried out both visually and by photographs At the same time, and also immediately before the attack, bombers will be used to disorganize communications behind the enemy lines to prevent reinforcements being rushed up when the attack begins. Fighter aircraft will be active in preventing any enemy machines from crossing the lines of the attacking army Spotter aircraft will assist the gunners in their preparatory barrages.

When the attack begins, close co-operation aircraft will be busy on reconnaissance work and will keep the commanders of the attacking army informed by radio as to how the enemy is being affected—where an encircling movement may be carried out, where some troops may have been cut off, and so on. They may also assist in individual battles by bombing or machine gunning enemy strongholds that do not fall easily. Meanwhile, the bombers will continue to harass the enemy lines of support. Fighter aircraft will be busy during the advance preventing enemy aircraft from carrying out counter measures.

Finally, when the advance has reached i‚ objectives, aircraft will keep the .nemy busy in every way possible while the new positions are consolidated.




HOW THE HOME DEFENCE SYSTEM WORKS

*An artist's impression of the co-ordination of units of the Home Defence Forces In actual practice they are not grouped so closely together Observer Corps report to Central Control Headquarters, giving information of the approach of enemy aircraft Headquarters telephone appropriate searchlight and anti-aircraft batteries and fighter plane stations Sound locators automatically train searchlights on the raiders, and predictors and range finders direct gunfire Fire ceases as interceptor fighters swoop into attack*

## CHAPTER V

# ON THE AERODROME

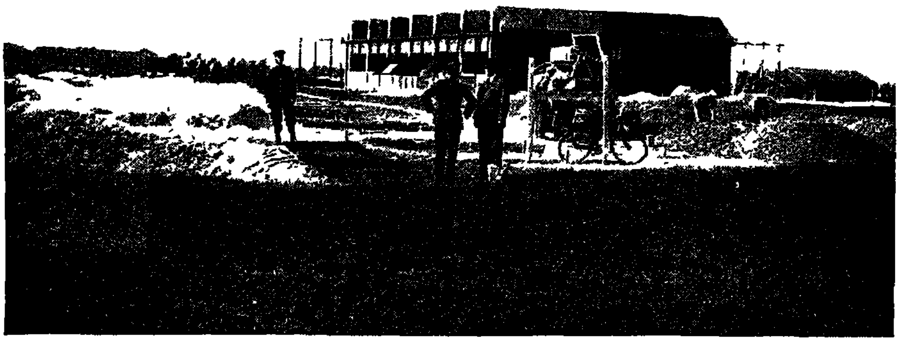
In the Royal Air Force, for every man in the air there must be five or more on the ground. The men and machines in the air are only the focal point of a colossal ground organization.

Although the duties of the men in the air form the more spectacular part of the work of the R A.F., the duties of the ground staff are just as important Theirs is the sort of work that would only be noticed if it went wrong, and because its efficiency depends on team work rather than on individual brilliance it rarely receives the praise it deserves. It must be remembered that the effectiveness of the R.A F. depends as much on the men on the ground as on the men who actually fly. Moreover, although ground work is carried out at a distance from the battle zone, it is by no means a "safe" job Aerodromes, as already pointed out, are particularly likely to be attacked in bombing raids.

Ground work can be divided into two sections There are the men who look after the machines, their equipment and ground organizations, and there are the men who look after the personal needs of

WOMEN'S AUXILIARY AIR FORCE GETS TO WORK

*Members of the Women's Auxiliary Air Force clean down a R A F lorry The W A A.F helps the R A F in the same way as the A T S helps the Army Members do clerical and technical work, cooking and a host of other non-combatant duties*



AN AERODROME UNDER CONSTRUCTION

*Peace time aerodromes are fine level fields with concrete runways and hangars In wartime aerodromes may have to be hurriedly improvised Even so, they must be well drained and fairly level Aircraft may be grouped around the edge of the field in the open*

the whole force and run its ground transport. Airmen have to be fed, their quarters attended to, and their supplies maintained. The organization of this latter section of ground work is in many ways similar to that of the Army, which is dealt with in detail in a later chapter.

### WOMEN'S AUXILIARY AIR FORCE

It will be enough to say here that the Women's Auxiliary Air Force provides considerable assistance in the performance of this work It also helps to some extent in the other section of ground work that may be termed technical For instance, some of the women of the W.A A.F. are trained as wireless telegraphists. But it is with the technical aspects of ground work and organization that we shall be concerned in this chapter

Most important of all are the aerodromes, for without them aircraft could not operate at all. At home the aerodromes used are those prepared in peace time—good aerodromes, fully equipped to make the pilots' work easy and straightforward so far as departure, take-off and landing are concerned. On the other hand, aerodromes near a battle front are often hurriedly prepared. Those that already exist may not be suitably situated, and even if they are, will not be large enough to accommodate all the aircraft For these reasons many more aerodromes have to be improvised It must be remembered also that French aircraft as well as British must be accommodated on the aerodromes in France.

In selecting a site for an aerodrome, one of the most important things to be considered is drainage If the ground is not well drained the aerodrome will be useless in wet weather It is even more important to select a well-drained site than a level one. Gentle undulations do not matter, and even sharp ridges can be removed more quickly than a drainage system can be constructed. Hedges and fences can be cut down and ditches can be filled in. The nature of the surrounding country is important in helping to hide an aerodrome, but the location is more likely to be fixed by wider questions of general strategy.

Another important consideration in the choice of a site is the hardness of the

ground and the sub-soil. As many bomber aircraft weigh ten tons or more there is a danger of the aerodrome surface being churned up or sinking. Something can be done to overcome these difficulties by building strengthened runways, disposed much in the same way as concrete runways. Sectionalized iron grids or rolls of coarse, strong, wire mesh or sections of metal grid are laid in the directions of the runs that the aircraft normally use (Fig. 1). Two or three such runways may answer all purposes. The mesh distributes the weight of the aircraft so that firm parts of the ground relieve the weaker parts of some of the strain.

Whether an aerodrome be permanent or temporary it must be made to look from the air as little like an aerodrome as possible. A permanent aerodrome is essentially a difficult thing to camouflage It is not the buildings that present the major problem, but the unbroken expanse of the landing area that is likely to catch the eye of the experienced pilot

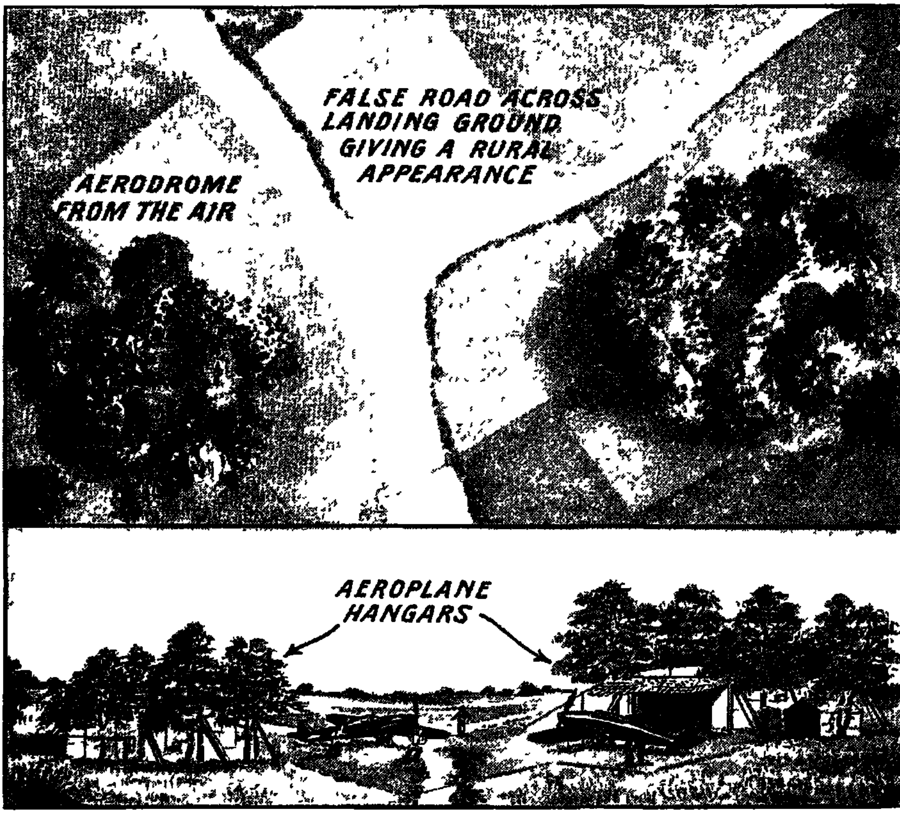
One method used to camouflage the landing area is to make an imitation road across it by means of tar and sand (Fig. 2). If this can be arranged to link up with a lane or road terminating at the boundary of the aerodrome it will be quite effective, and such imitation roads have even been continued by suitable painting directly across hangars and buildings.

### COLOUR IN CAMOUFLAGE

In camouflaging buildings the aim is to break up their straight lines with contrasting colours that blend with the natural colours of the ground around them. Sides of buildings, because they are seen at an angle from above, are best treated with slightly lighter colours than the roofs. Sometimes a coarse netting will break up the lines of a large rectangular building far better than paint.

A WARTIME AERODROME RUNWAY

**Fig. 1.** *Hurriedly prepared wartime aerodromes must have good strategic sites, be fairly level and well drained Rolls of coarse, strong wire mesh trail across the field to form runways and prevent heavy bombers from churning up the surface of the ground*




TWO METHODS OF CAMOUFLAGING AN AERODROME

**Fig. 2.** *Aerodromes must be concealed from the enemy Imitation roads are built across the landing area with tar and sand (top) Aircraft on the ground are grouped around the boundaries Canvas hangars are improvised and concealed beneath trees or branches*

At temporary aerodromes hangars are seldom provided for the aircraft, particularly if they are large bombers. Modern aircraft can stand up to prolonged exposure but they must be camouflaged from observation. All military aircraft are camouflaged with drab coloured paints. But this paint alone is not sufficient when they are stationary in large numbers on the ground To line them up would obviously increase the ease with which they could be spotted from above. They are therefore distributed singly or in twos and threes around the boundaries of the aerodrome, full advantage being taken of the concealment offered by high hedges, trees and other natural cover.

This distribution of aircraft is also valuable should the aerodrome be spotted and a bombing raid ensue. Then as the aircraft on the ground are widely separated, it would be almost impossible for the raiders to damage them all.

Machines left out in the open have canvas covers placed over their engines (Fig. 3). These help to hide the tell-tale lines of the engines and prevent the reflection of light from them. Further disguise may be carried out with branches of trees and netting (Fig. 4), and many ingenious

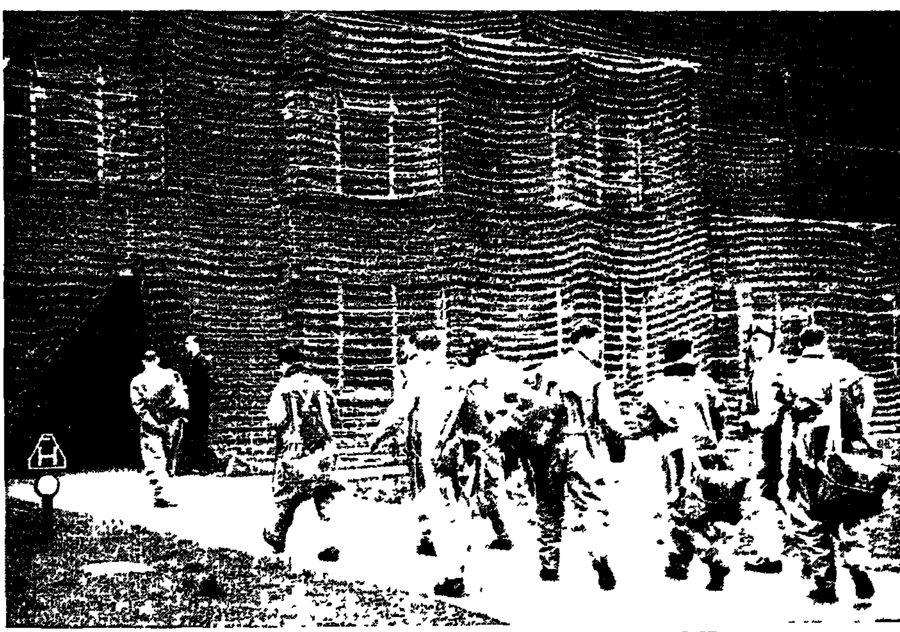
schemes are used to make the aircraft tone in with their immediate surroundings. Always it has to be remembered that the aircraft may have to take off at short notice, so that the camouflaging must be of such a nature that it can be removed quickly.

All aircraft not being repaired are kept ready to take off at a moment's notice. In the case of fighters this readiness often extends to running the engines every half hour or so to keep them warm Snow falling on the aircraft is swept off at regular intervals and the wheels are watched to see that they are not sinking into the ground causing the aircraft to be bogged Bombs, which are kept in the open near the aircraft ready for loading, are also inspected and cleaned at intervals. In addition to these checks, whether the aircraft are used or not, all moving parts are inspected each day to see that they are properly greased and oiled, and any adjustments required are made. All these duties make heavy and continuous demands on the ground staffs and require a very elaborate organization.

### THE GROUND STAFF

The ground staff of an aerodrome is made up of experts in a wide variety of subjects For convenience we can divide them into two main groups (Fig. 5). The first group includes the men who look after the aeroplane, engine and airframe. They include fitters and riggers, instrument makers, electricians, radio mechanics and armourers. The second group includes the men who staff the aerodrome itself Among them are the meteorological staff, photographic experts, parachute repairers and re-packers, radio operators, ambulance men, firemen.

We will now turn to a more detailed account of their duties, starting with the first group, the men who look after the



HOW LARGE BUILDINGS ARE CAMOUFLAGED

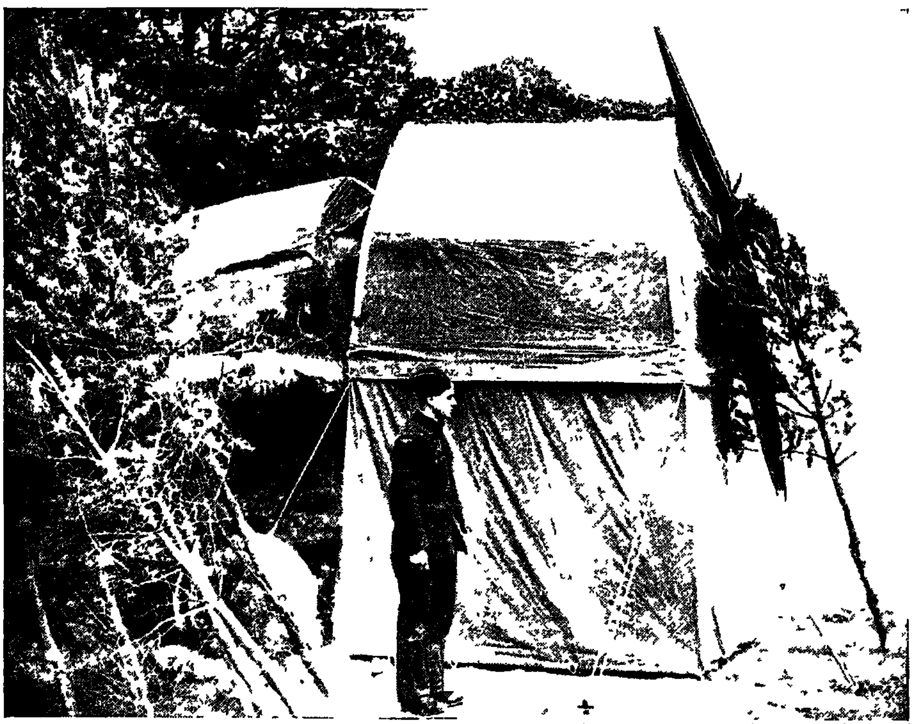
*One way of breaking up the straight lines of a building to camouflage it The sides of this hangar are festooned with strips of light-coloured cloth Coarse netting can also be used*

aeroplane, both engine and airframe.

First the fitters and riggers—engineers and mechanics who look after the aircraft itself. The lives of the men who fly the aircraft depend on the meticulous care with which the ground engineers and mechanics carry out their routine inspections. The men who perform this ground work have built up a fine sense of responsibility. No matter how difficult the conditions in which they work or how cold the weather to which they are exposed, every detail down to the smallest nut and split-pin regularly receives its due amount of attention.

The daily maintenance work, the more extensive periodic overhauls, and the repairs to damaged aircraft, are carried out by airmen with varying grades of skill. In each grade there are men, skilled in various "trades," to deal with different parts of the aircraft. Fitters deal with the engines, and riggers with the airframes. An airframe is the whole of the aircraft apart from the engines and includes the various items of equipment such as instruments, radio and armaments.

As soon as aircraft return from operations, they are handed over to the ground staff. While the tired pilots make their reports, eat and take their rest, the ground staff work night and day getting the aircraft into condition for further duties. Every part of the aircraft is inspected for damage, tested and adjusted as necessary. Sometimes damage is obvious at a cursory glance, sometimes it is revealed only by careful tests. When damage is not too



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CANVAS COVERS THAT PROTECT AIRCRAFT

**Fig. 3.** *Aircraft left out in the open have canvas covers placed over the engines, and with the assistance of a few branches the lines and reflecting surfaces are hidden from view.*



NETTING USED TO CAMOUFLAGE AN AIRCRAFT

**Fig. 4.** *A sentry, standing in the snow, guards this R A F machine at an improvised wartime aerodrome. The heavy netting makes the aeroplane almost invisible from above*

great, the aircraft are repaired in the workshops that are attached to every aerodrome (Fig. 6). With modern aircraft such repair work is generally a matter of replacing the damaged part with a spare.

Should an aeroplane return so badly damaged that the damage can be made good only by completely rebuilding the machine, it will be partly dismantled and sent to a central depot where such damage is dealt with. Here, no matter how badly the aircraft is damaged, it can be made use of in some way. Perhaps two or three badly damaged aircraft are taken to pieces and the sound parts are built up

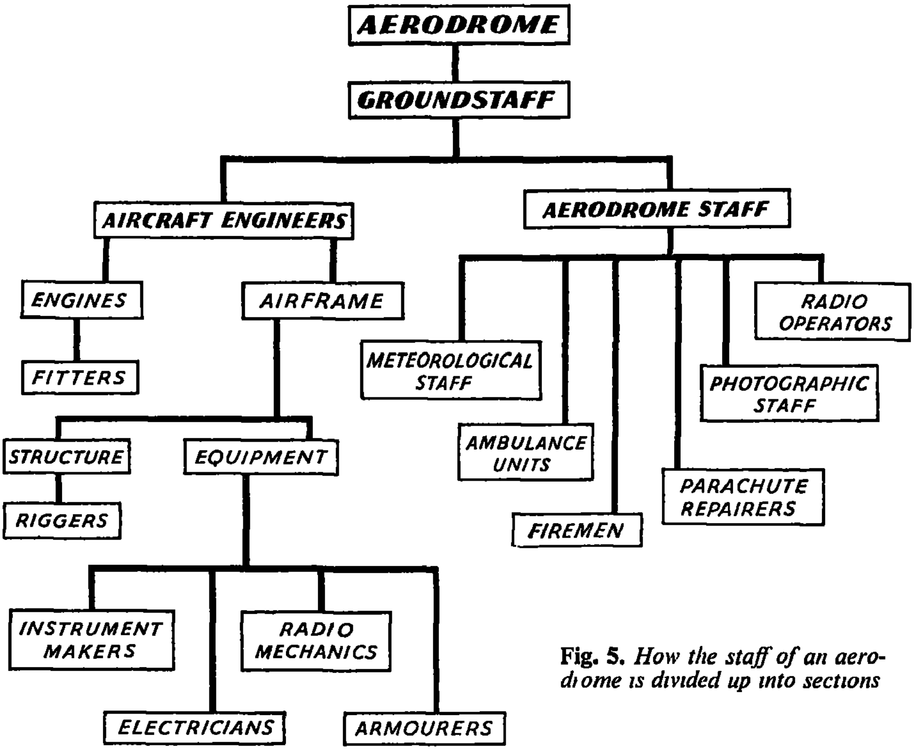



Fig. 5. *How the staff of an aerodrome is divided up into sections*

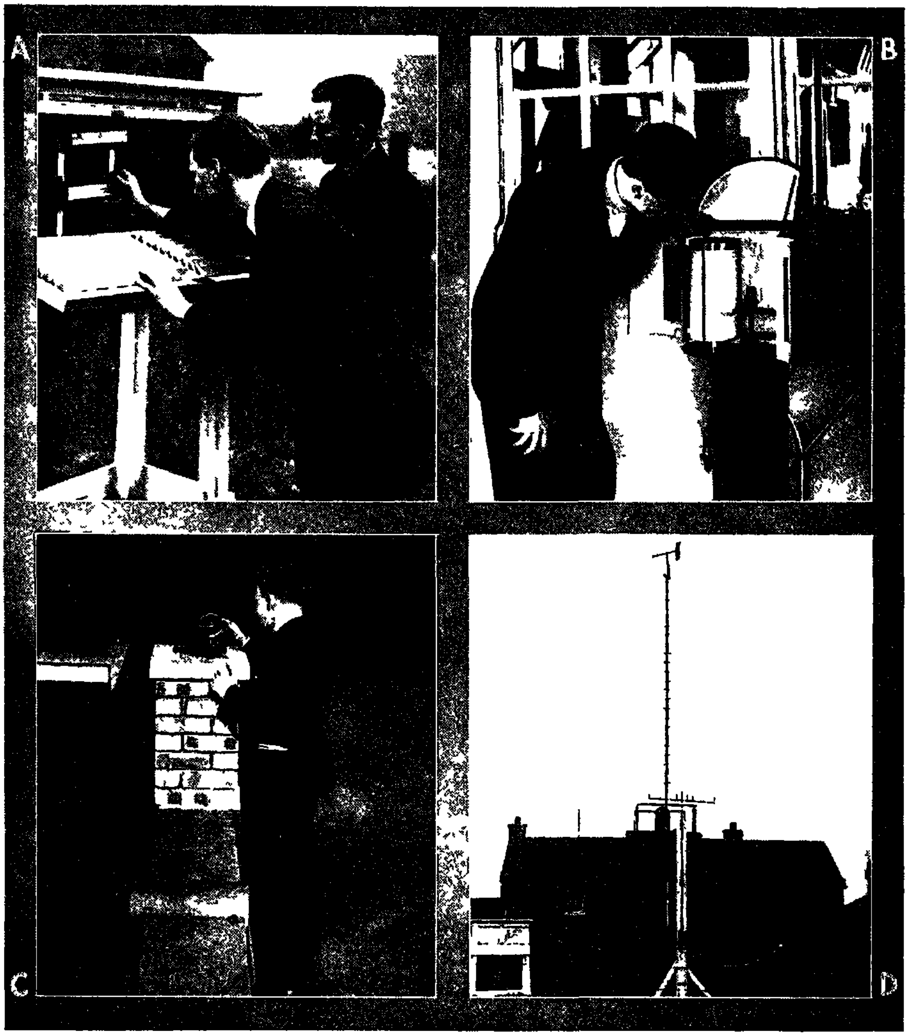
into one good machine. In a rebuilt aircraft the engines may come from one damaged machine, the body from another and the wings possibly from a third. All aircraft used will be of the same type.

### MAINTENANCE OF EQUIPMENT

Having dealt with fitters and riggers we turn next to the men concerned with the maintenance of an aircraft's instruments and equipment. These instruments and this equipment are cared for by men with special qualifications. Instrument makers deal with the numerous important engine instruments, compasses and similar items. Electricians overhaul the electrical equipment, including the magnetos. Radio mechanics overhaul the radio transmitting and receiving sets. Armourers overhaul the guns, bomb racks and release gear. Each airman is fully competent in his particular task, and is able to carry out repairs or adjustments accurately and quickly.

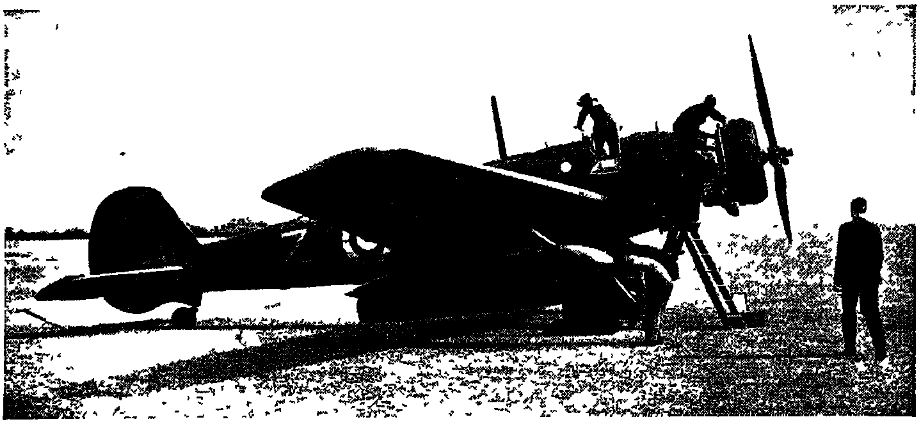
We now come to the second group, the men who staff the aerodrome itself. Most aerodromes have their own meteorological staffs, but there may also be meteorological stations at places where there are no aerodromes. Such places are chosen because their situation makes them most suitable for forecasting the weather.

The meteorological staffs collect every possible detail about the weather—temperatures, visibility, wind velocity, wind direction, barometric pressure, and so on. Wind speed and direction are of great importance. Not only does the velocity of the wind increase with height, but it may also change its direction. Wind velocity and direction at various heights can be calculated once a knowledge




INSTRUMENTS USED TO FORECAST WEATHER

*The Meteorological Department of the R A F, which supplies the Air Ministry with details of present and future weather conditions, uses many delicate instruments, some of which are shown on this page Picture* A *is a close-up view of the Stevenson screen, a container devised to allow instruments to react to the weather without being exposed to damage by it It may hold instruments like the thermograph which makes a continuous record of the temperature, and the hydrograph which records the relative humidity of the surrounding air Pictures* B *and* D *show the Dines pressure tube anemometer At the top of the sixty-five-foot mast (picture* D*) is an instrument that registers the velocity and direction of the wind It is placed on top of a high mast in order to avoid eddies caused by the nearby buildings This instrument is connected with the one inside the building (picture* B*), called an anemograph Here the velocities and directions registered by the instrument on top of the mast are recorded on the chart paper wrapped around the cylinder In picture* C*, an official of the department is taking a reading from an instrument that records the amount of sunshine*

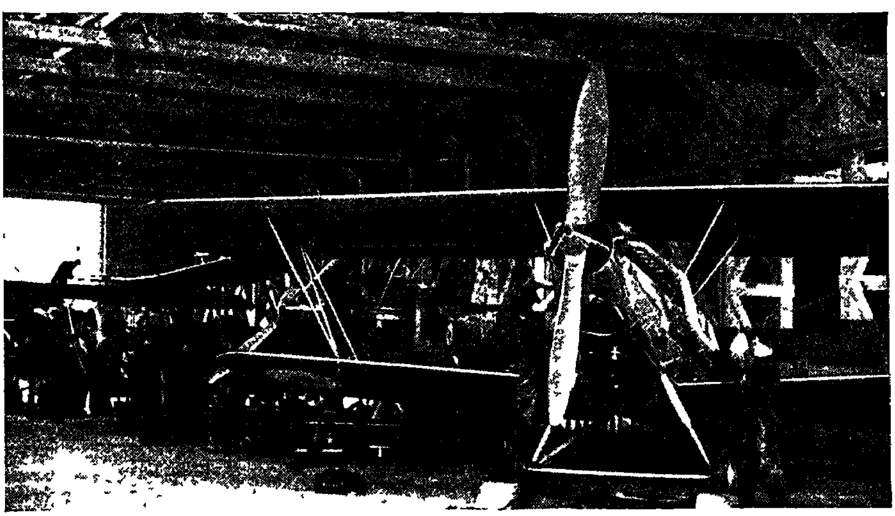


RUNNING REPAIRS IN THE FIELD

*Fitters and riggers at work on a "Wellesley" long-range bomber These members of the R A F. look after the aircraft itself Fitters deal with the engines and riggers with the airframe*

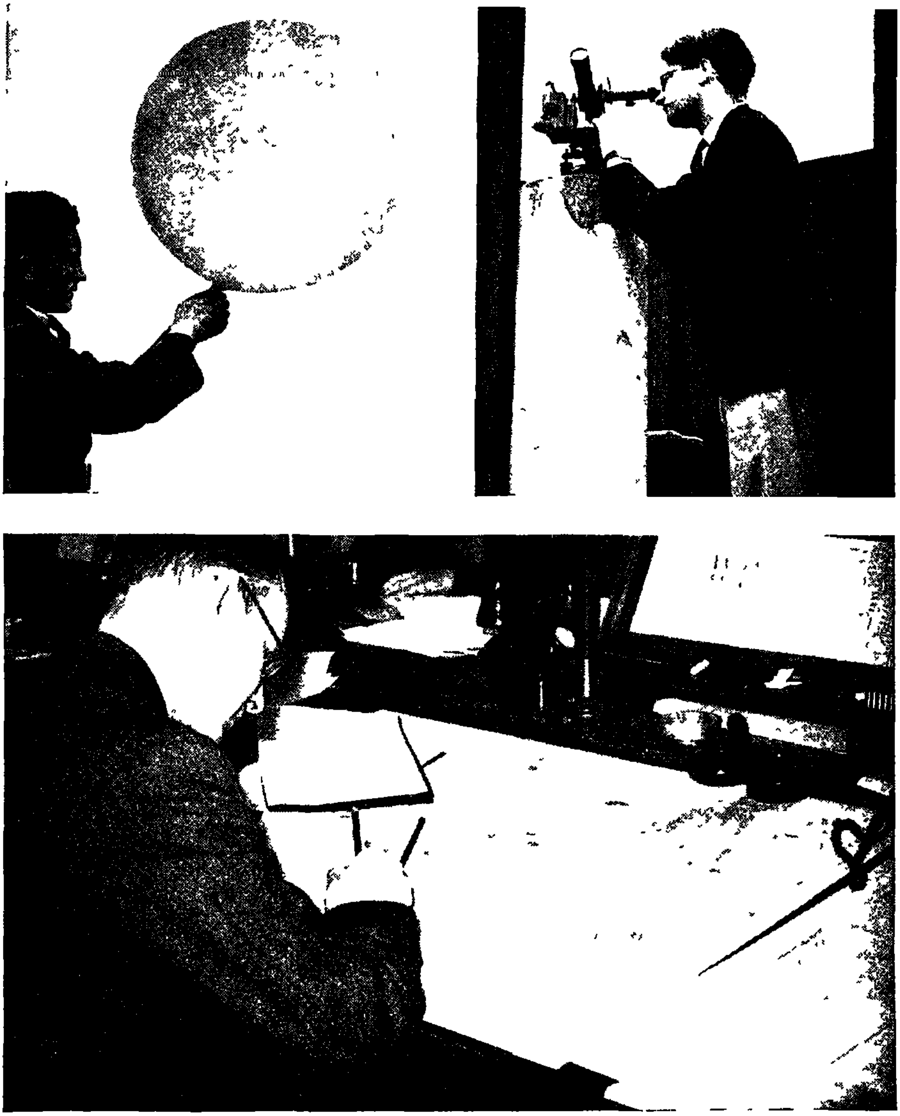
of the wind velocity and direction at a given low altitude is obtained. As a check on the accuracy of these calculations, the velocity and direction of the wind at various heights is periodically measured.

For this purpose small hydrogen-filled balloons are used When they are released they travel at the speed of the wind, their speed varying as they attain different heights. By means of theodolites used by observers on the ground, the exact position of a balloon at, say, every 500 feet of height is measured (Fig 7). From these measurements the velocity and direction of the wind is ascertained



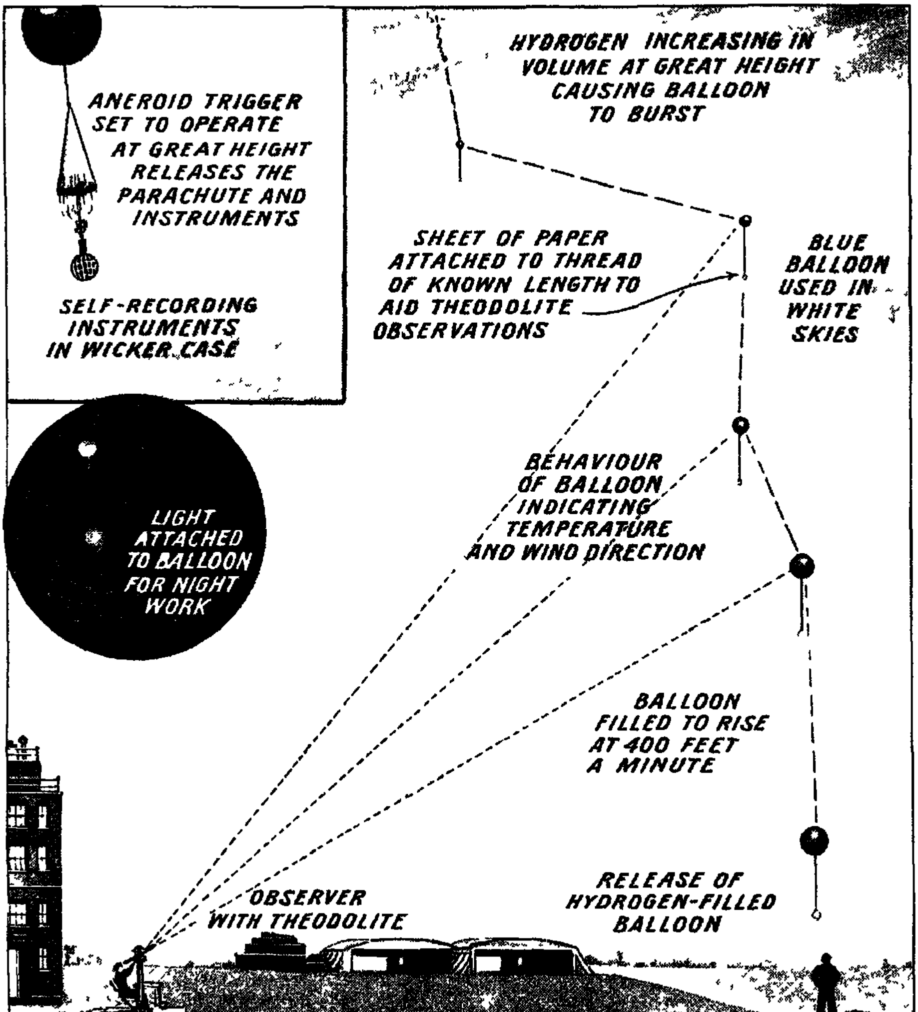
GROUND STAFF AT WORK IN A HANGAR

**Fig. 6.** *After every flight aircraft are handed over to the ground staff Every part is inspected, tested and adjusted as necessary Most damaged machines can be repaired in the workshops that are attached to every aerodrome Others are sent to a central depot for repair*



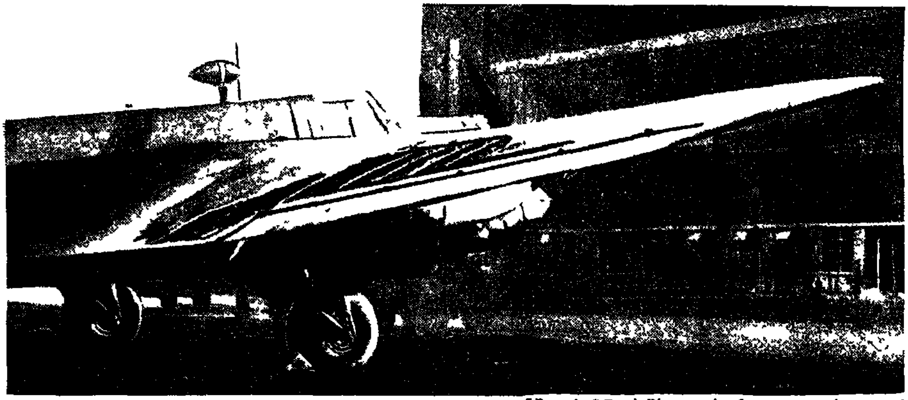
HOW A WEATHER MAP IS MADE

*Hydrogen-filled balloons are released from weather posts (top left) and are used to test the direction and speed of the wind Further details of this work are given in the diagram on page 150 Meteorologists use a theodolite (top right) to take observations of the ascent of the balloons From weather observations received at the Meteorological Department of the R A F, weather maps are compiled (bottom) Detailed forecasts for particular areas can be copied on to special message forms and sent to the aerodromes concerned An example of the type of weather map generally compiled is given on page 153*




BALLOONS FOR RECORDING WIND AND WEATHER

**Fig. 7.** *A small hydrogen-filled balloon is released from the aerodrome It rises rapidly and travels forward at the speed of the wind An observer with a theodolite (an instrument for measuring height and position) watches through a telescope attached to the apparatus and, from the behaviour of the balloon, calculates the speed and direction of the wind at various heights Readings are taken every minute until the balloon is out of sight The speed of the balloon's ascent indicates the temperature at various altitudes White balloons are used against clear blue skies and red ones against patchy light and dark skies Sometimes self-recording instruments in a wicker case are sent up attached to a balloon An aneroid trigger, set to operate at a great height, releases them and they float to the ground, borne by a parachute Other and more complicated apparatus is used by the Meteorological Department of the R A F, some details of which are given on pages 147 and 149*



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A BADLY DAMAGED AIRCRAFT FOR THE CENTRAL DEPOT

*This damaged aircraft will be sent to a base depot for repair and overhaul There it may be stripped and its engine or body used to build a new machine*

for different altitudes When the balloons reach a certain height, reduced atmospheric pressure makes them burst

Although the weather information collected locally is of value to pilots setting out from that point, a central station for the collection of all weather observations is essential From the information supplied by the various weather posts, the staff at the central station can compile weather maps on the lines of that illustrated in Fig. 8 These maps are invaluable to pilots flying over long distances, and enable forecasts of weather changes to be made

Other important work is in the hands of the photographic experts of the ground staff They are concerned with overhauling and maintaining the cameras used on aircraft and the loading of new film. In addition, they develop and print the films brought back by the

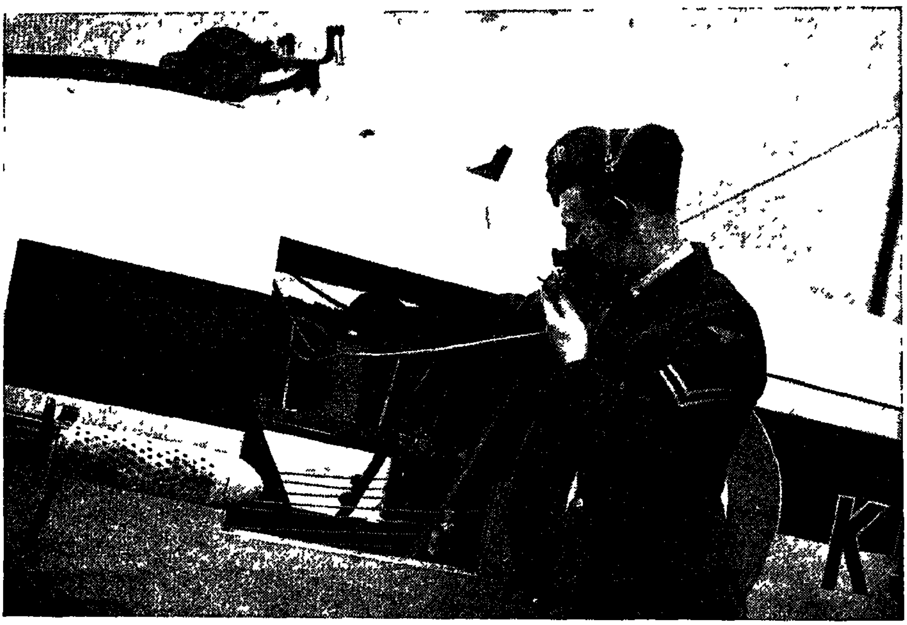
SKILLED ARMOURERS OF THE R A F AT WORK

*Armourers in an aerodrome workshop overhaul machine guns from a plane just returned from a flight Machine guns, bomb racks and release gear must all be checked*

reconnaissance aircraft. This work has to be carried out at great speed as the information in the films may be vital, and the photographers must not spoil a single exposure in the developing process.

When a reconnaissance aircraft returns from a flight an airman runs out to meet it, grabs the exposed films (Fig. 9), and races with them to the dark room where the developing solutions are ready waiting. Every possible device is used to speed up developing and printing, and so effective is the organization that prints from the exposed films will often be in the hands of the intelligence officer before he has heard the observer's verbal report and finished questioning him. Some idea of the technical processes involved in developing, printing and preparing these aerial photographs can be gathered from Fig. 10

Among the other vital duties of ground staffs are those covering parachutes and radio communication. In wartime, parachutes come in for much hard treatment. It is, therefore, more important than ever that they should receive regular inspection. The inspection of a parachute requires that it shall be completely taken out of its pack and unfolded. Re-packing must be carried out by skilled people.

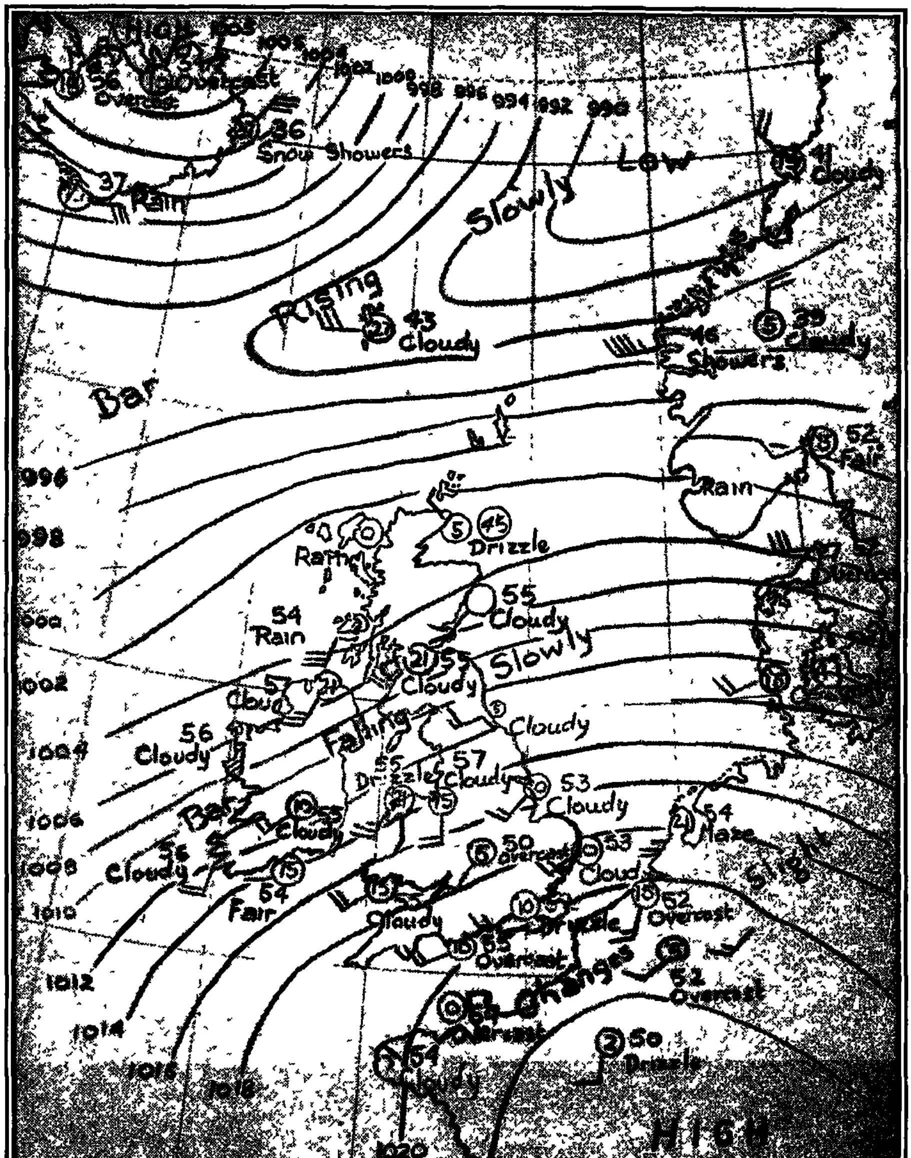


ROUTINE INSPECTION OF AN AIRCRAFT'S INSTRUMENTS

*An aircraft's instruments are all checked after each flight Here a radio mechanic attached to the ground staff is testing the wireless set in an aircraft*

An airman's life may very often depend upon his parachute and his ability to use it. A note on the use of parachutes may not, therefore, be out of place. When an airman jumps from the aircraft, he must wait a few seconds before pulling the rip cord of his parachute, otherwise there will be a danger of the parachute fouling some part of the aeroplane that may also be falling.

Pulling the ripcord first releases a small parachute known as the "pilot" (Fig. 11). The force of air on this small parachute




A TYPICAL WEATHER CHART

**Fig. 8.** *This is a typical weather chart issued by the Meteorological Office The continuous black lines are isobars, indicating atmospheric pressure, the black figures indicating air temperature The arrows show wind direction and force Weather conditions are also shown These maps are compiled from reports received both from meteorological stations and ships at sea. Copies are distributed to aerodromes Detailed weather forecasts can be given to pilots whose duties take them over special routes*

[British Official Photograph Crown copyright reserved

HANDING IN RECONNAISSANCE PHOTOGRAPHS

**Fig. 9.** *An airman runs out to meet a returning reconnaissance aircraft and rushes exposed films to the dark room There they are rapidly developed and printed*

pulls the folds of the main parachute from the pack.

When descending in a parachute the airman has no idea of the rate at which he is falling None the less his contact with the ground is equivalent to a jump from a wall six to ten feet in height. It is, therefore, imperative for him to relax as he nears the ground and he is assisted to do so by the design of the straps that support him. These are arranged so that he sits in them rather than hangs from them. There is a quick-release device on the harness (Fig. 11) that enables him to free himself from the parachute. This device is also necessary should a descent end in water, when, without it, the parachute would prevent him from swimming.

The parachutist is not entirely helpless while in the air. He is able to exercise a certain amount of control over the direction of his descent He achieves this control by pulling downwards on the lines linking the canopy of the parachute to the supporting straps. Thus, if he finds himself coming down over buildings, he can guide himself to a more suitable spot for landing

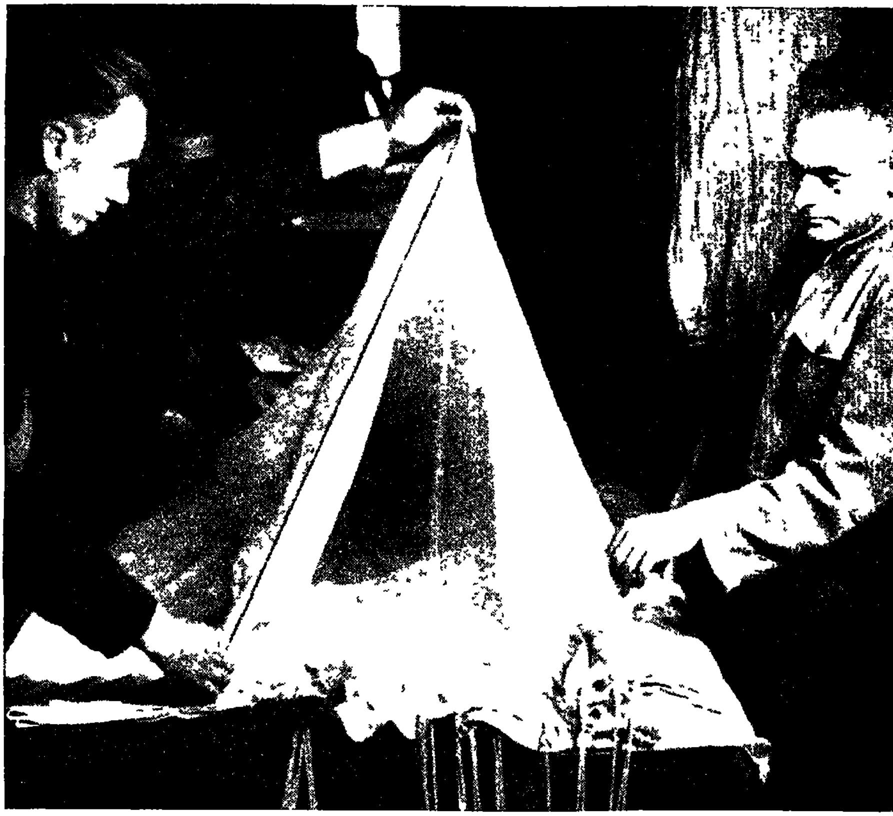
When he has landed, he has to spill the air from the canopy by pulling on the supporting lines If there is a strong wind this may be difficult, and the


HOW AERIAL PHOTOGRAPHS ARE DEVELOPED AND PRINTED

**Fig. 10.** *Bottom right shows method of preparing photographs for stereoscopic vision This makes contours of the ground visible, and camouflaged buildings may be detected*


THE PARACHUTE—AN AIRMAN'S "LIFEBELT"

**Fig. 11.** *A diagrammatic explanation of how a parachute and its quick-release device work. As soon as the locking pins are released by the control disc the airman is free. A small pilot parachute opens the main parachute when the ripcord is pulled*

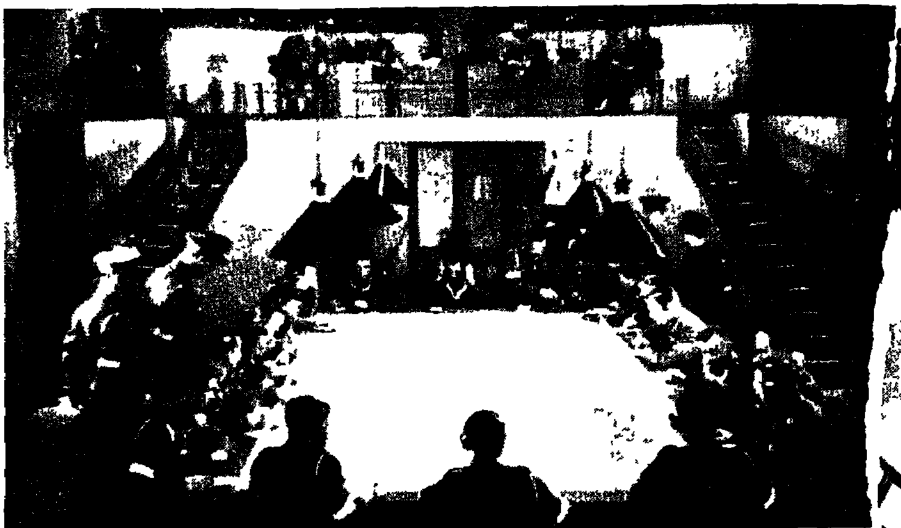


PACKING A PARACHUTE

*Australian airmen are here re-packing a parachute after inspection (top) No parachute will work unless packed in a special way The importance of this work may be gauged from the picture on the left. The life of the airman leaping into space depends upon his parachute*

parachutist may find himself in danger of injury from being dragged across the ground. Here again his quick-release mechanism is invaluable.

We have already mentioned the radio operators at aerodromes. These are the operating staff of ground radio stations, and must not be confused with the mechanics who keep radio sets in repair The principal use of ground radio stations is to maintain contact with aircraft operating from the aerodrome at



[G B Instruc

HEART OF BRITAIN'S HOME DEFENCE

**Fig. 12.** *This picture, like Figs 13 and 14, is a careful reconstruction from an authe[n] British film on the R A F Here is Central Control Headquarters of Home Defence. A[r]o[und] the table in the centre of the picture sit the plotters On the balcony above are the office[rs in] command The progress of enemy bombing raids is followed on the map on the table, [and] appropriate defence measures taken Contact is maintained with all defence un[its]*

which the radio station is situated. With bombers, for reasons explained in Chapter I, such contact will be maintained only at the beginning and end of each flight. But with fighter aircraft, and some reconnaissance aircraft, contact will be maintained the whole time the machines are in the air With intercepter fighters, particularly those operating on the Home Front, this contact is essential. Information as to the course, height and speed of approaching bombers, and also as to any changes they may make in their course, must be signalled to the fighters as soon as it is known

### WORK OF LISTENING POSTS

This vitally important information is obtained from a series of listening posts and observers, stationed all round Britain's shores, and it is passed direct to Central Control Headquarters of Home Defence (Fig. 12). At this Central Control Headquarters, where informati[on] from all listening posts is available, t[he] staff are able to work out the probab[le] objectives of any group of approachi[ng] bombers.

Headquarters always maintain com[munication] with every aerodrome whe[re] fighters are stationed. According [to] need, they detail one or another aer[o]drome to undertake the task of fightin[g] off the approaching raid. Central Co[n]trol is also responsible for setting i[n] motion the whole complex organizatio[n] of Home Defence. Some aspects of this defence system are seen in the illustration on page 138.

Any further information about th[e] course of the bombers is at once passe[d] to the aerodrome concerned, and th[e] further information must be immediate[ly] transmitted to the pilots of the figh[ter] aircraft. In consequence the job of t[he] radio operator, who is in touch with su[ch]

pilots, is of first-class importance. It is his duty to maintain constant contact with these pilots while they are in flight. He works in the Operations Room of the aerodrome (Fig. 13).

This Operations Room is the nerve centre of the aerodrome's organization. Besides the radio operator, it holds the administrative officers As soon as any order is received from Control Headquarters, they at once work out the course the fighters are to take so that they will contact the bombers in the shortest possible time. The Operations Room is connected to every part of the aerodrome by land lines, and necessary instructions are at once issued. Fighter pilots, who are always standing by, rush to their aircraft, the engines of which have already been started up. They clamber aboard and at once establish radio telephonic communication with the Operations Room. Very often the order to take off and final instructions are given by radio while the aircraft are still on the ground. Within a few moments of this order being received, the fighters are roaring into the air to engage raiders.

### CONTACT WITH PILOTS

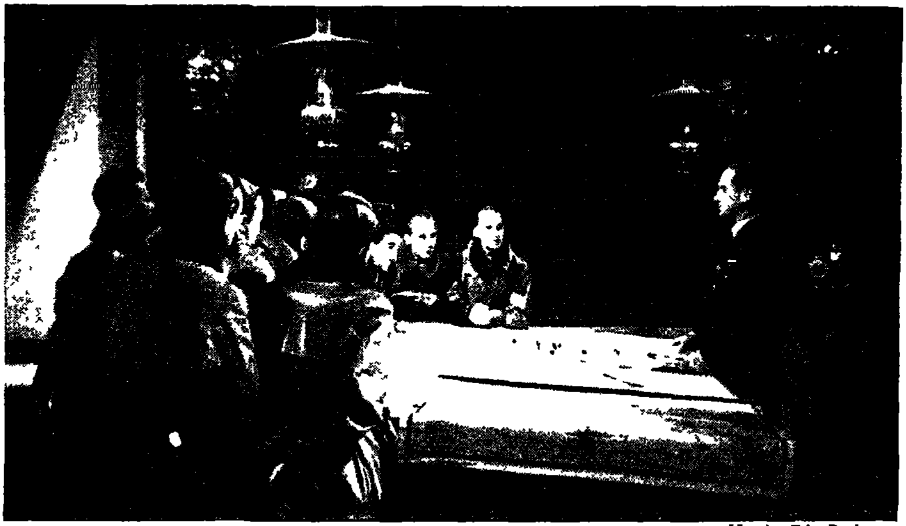
Because of the two-way telephone contact, the pilots can not only report progress immediately, but can also be informed at once of any further information, such as changes in the bombers' course or height, that comes through from Control Headquarters.

When the raiders have been driven off,

[London Film Productions

NERVE CENTRE OF AN AERODROME

Fig. 13. *This reconstruction shows the Operations Room of an aerodrome On the left is the radio operator who maintains contact with headquarters and with aircraft in the air. In the centre the commanding officer is issuing his instructions to fighter aircraft by telephone. Telephone lines run to every section of the aerodrome On the walls can be seen large-scale maps of the sections over which the aircraft operate. Here all actions are planned.*



[*London Film Productions*

LAST-MINUTE INSTRUCTIONS FOR A BOMBING RAID

**Fig. 14.** *In this picture, selected officers and airmen have been summoned to the Operations Room of an aerodrome just before they take off on a bombing raid. Detailed plans for the raid have been prepared in advance and a senior officer is explaining them.*

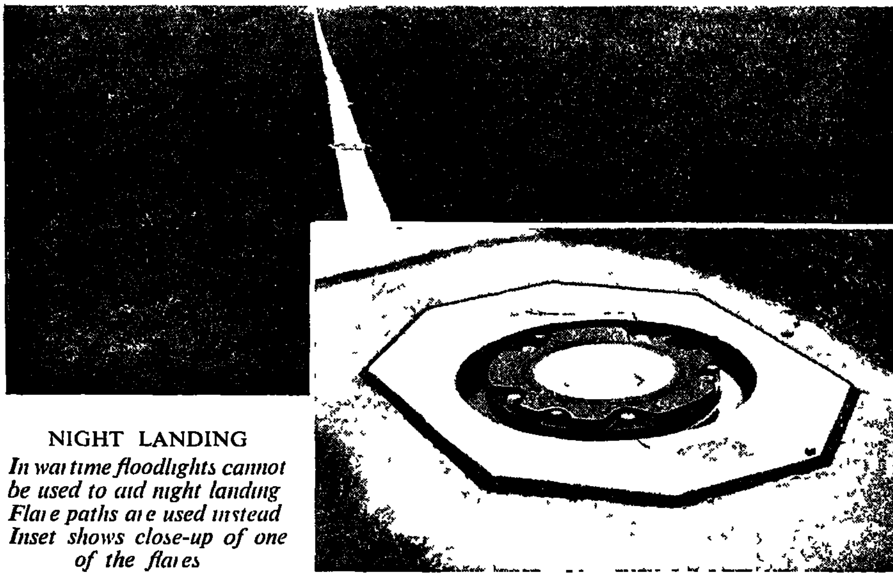
or when they have passed out of the sector over which the fighters are operating, the fighter pilots are recalled. Close contact with the fighters is essential at this point as they must be prevented from running into sectors where they might be likely to be hit by fire from their own anti-aircraft guns.

In the case of operations by bomber aircraft, preparations after receiving instructions from headquarters will take much longer than in the case of fighters. Here again, before they can take off a great deal of work has to be done by the aerodrome staff. First of all, senior officers will plan the course for the flight, then detailed instructions about the courses will have to be worked out, and copies made for the "captains" of each aircraft. When the time for departure is nearing, the selected officers and airmen will be sent for, and a senior officer will explain to them details of the nature of the raid on which they will go (Fig. 14).

Meanwhile, mechanics are at work preparing the aircraft. Engines are started, warmed up, and tested. Armaments are checked over, ammunition for the guns put aboard, and the bombs loaded into position. On the efficient way in which this work is carried out will depend the success of the raid and the safety of the bomber's crew.

It will be realized that the proper organization of all this work depends on the Operations Room again. Despite the tremendous activity, the rushing in and out of messengers, the ringing of telephone bells, the raucous voices from loudspeakers, the bustle is extremely orderly. Loudspeakers figure prominently in the Operations Room, for the receiving apparatus of the radio operator is always connected to a loudspeaker in order that the senior officers can hear what the pilots say immediately. Even seconds are of vital importance when enemy aircraft have to be intercepted.

Maps, too, are to be seen everywhere—on the walls and on tables and a special



NIGHT LANDING
*In wartime floodlights cannot be used to aid night landing Flare paths are used instead Inset shows close-up of one of the flares*

staff of expert map plotters and readers is always on hand. In the case of an aerodrome to which fighters are attached, the maps will cover the sectors over which that aerodrome operates. But in the case of an aerodrome with bomber squadrons, the maps may be far more extensive and may include naval charts and aerial maps of large areas of the Continent.

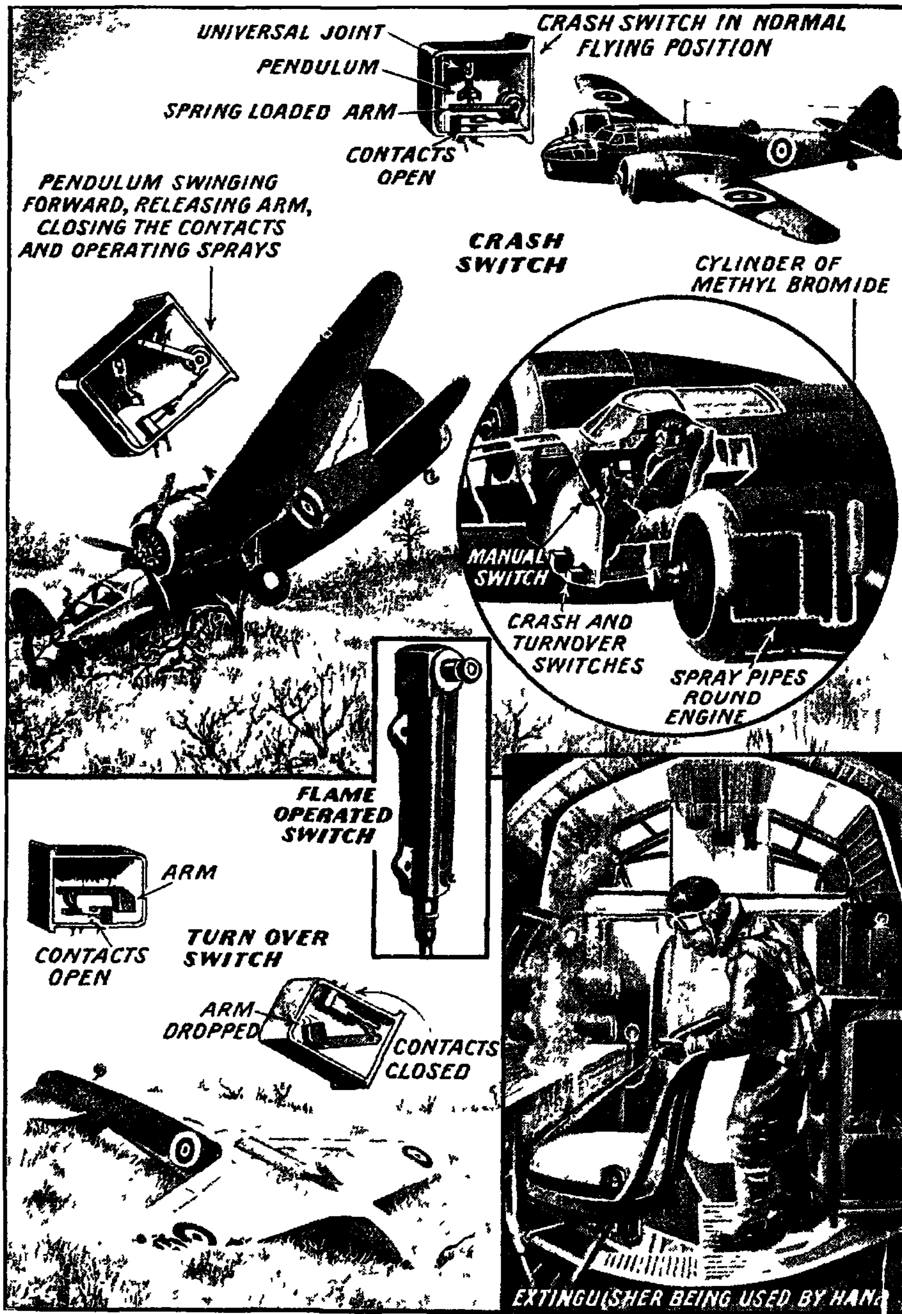
### LANDING AT NIGHT

Another "safety duty" of the ground staff is the control of lights of the aerodrome. In wartime the night bombers usually take off in darkness, but sometimes they are aided by floodlight or flare paths. Full floodlighting such as is used at civil aerodromes in peace time, can seldom be used for fear of indicating the position of the aerodrome to enemy aircraft.

Lighting is used more frequently to assist the bombers to land. When the returning aircraft indicate by radio that they are near their aerodrome, a flare path may be lit to help them to land. The flares are set out in the form of a capital T or an inverted L, arranged with the long stroke or stem in the direction of the wind, and the pilot lands alongside the long stroke and towards the short stroke

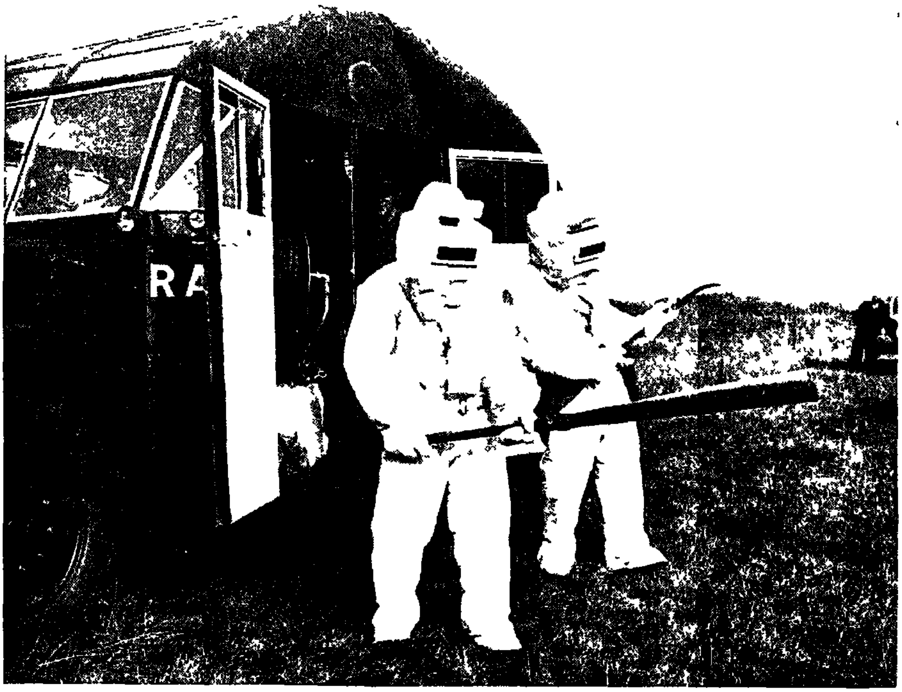
There are other precautions to be taken when aircraft are returning from operations. Some crashes on landing must be expected and prepared for. A damaged aeroplane may be holding together just sufficiently for the pilot to return to his aerodrome, but it may break down under the greater strain of landing. Or a wounded pilot may not be in a condition to make a good landing although he has managed to fly his aircraft home. Ambulances therefore stand by in readiness to race to any landing aircraft that may require assistance.

The greatest danger to aircraft has always been fire, and in wartime this danger obviously increases. When a machine loaded with petrol crashes, or when its tanks are pierced by shell fragments or machine gun bullets, it will




HOW AIRCRAFT ARE PROTECTED FROM FIRE

**Fig. 16.** *Automatic and hand-operated switches work chemical sprays in case of fire*




RAF FIRE FIGHTERS IN ASBESTOS SUITS

**Fig. 17.** *If an aircraft bursts into flames as it lands, a motor fire engine rushes to the scene While rescue work is carried out, a special type of foam spray is used to extinguish the fire These firemen are wearing asbestos suits that enable them to work unharmed in fierce flames*

take very little to set it ablaze. For this reason modern aircraft are often fitted with ingenious devices to combat this danger Some of these devices in general use are illustrated in Fig. 16

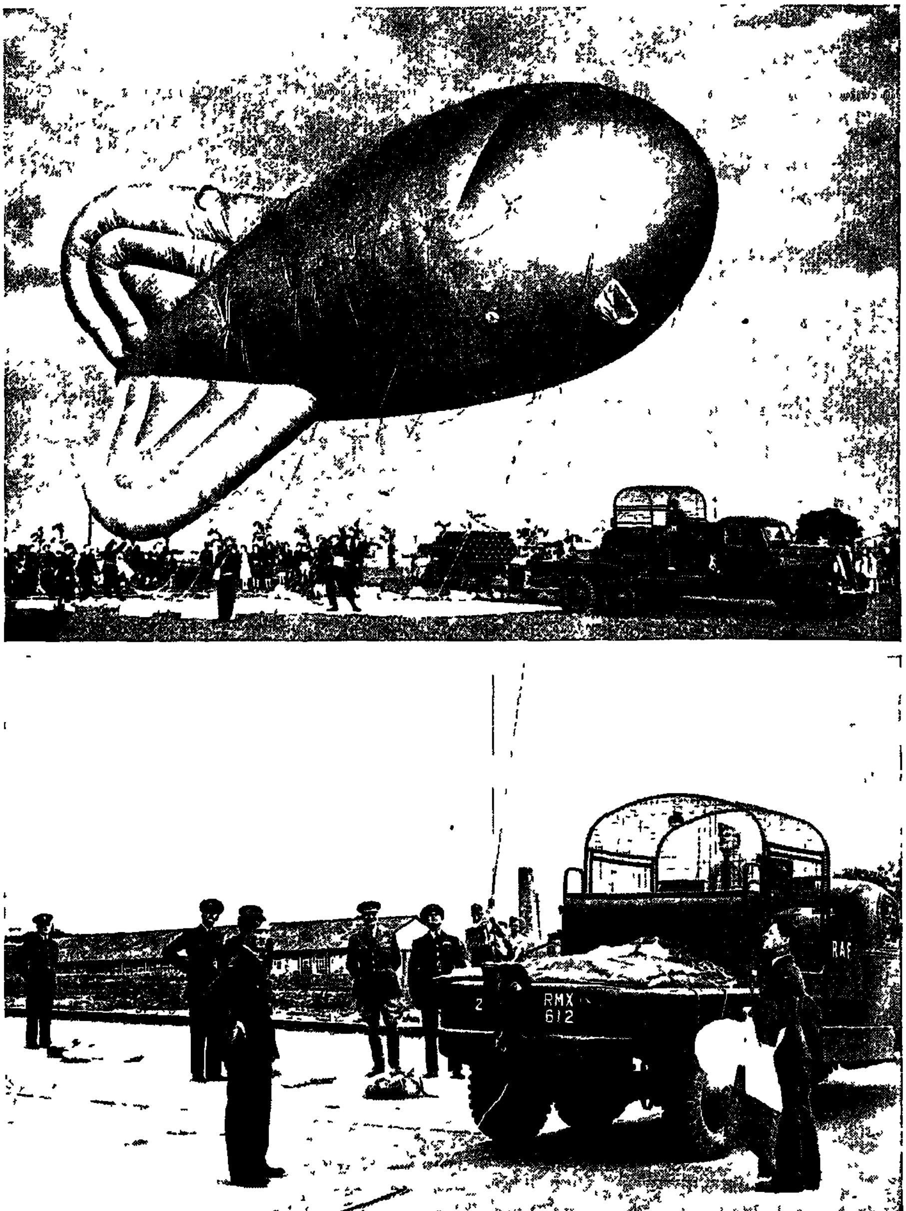
### SCIENTIFIC FIRE FIGHTING

Despite these precautions it is quite common for an aircraft that crashes to burst into flames. Motor fire engines, equipped with every scientific device for extinguishing fires, are kept ready at every aerodrome for immediate use. A typical fire engine is seen in Fig. 17. The duty of the firemen is not so much to save the aircraft that has caught fire as to rescue the crew and pilot before the petrol tanks explode, or even after if possible. Attempts will also be made to save any photographs that may have been taken during the flight. Quick work is imperative and while the flames are sprayed with chemicals to extinguish or reduce them, men with hatchets release any members of the crew who may be trapped or unable to help themselves.

### ASBESTOS SUITS

Many devices have been developed to aid the rescue parties in their work. For instance, there is a special asbestos suit that completely envelops a man, special viewing panels being let into the hood that covers his head (Fig. 17). Wearing one of these suits, the rescuer is able to walk unharmed amongst the flames to rescue the members of an aircraft's crew.

In conclusion we must add a word




HOW A BARRAGE BALLOON IS HANDLED

*The top picture shows an ascending balloon It has been filled with gas from cylinders on the trailer behind the lorry Note the vent hole in the forward end Wind blowing through this hole fills out the tail fins to keep the balloon stable. The picture below shows how the man operating the winch is protected by a wire cage.*

about the Balloon Barrage, the maintenance of which is part of the duties of the R.A F.

Balloon barrages are used to defend cities or strategic naval and military points, against air attack Each barrage consists of a large number of balloons which are not arranged in a circle round the point to be defended, but are dotted all over it according to a set plan. A barrage arranged in this way is far more effective than would be a simple perimeter arrangement.

Raiding aircraft must beware not only of the balloons, but also of the cables which hold them to the ground The balloons are, of course, easily visible in the daylight to pilots of aeroplanes, but the cables are not, and if a bomber hit, even with its wing tip, one of these cables it would certainly crash.

### KEEPING RAIDERS HIGH

The height to which balloons can ascend can be regulated according to particular requirements, but if necessary the balloons can be sent up to a height of 10,000 feet or more. Raiding aircraft, in order to avoid the barrage, must therefore fly high, and indeed the chief object of the barrage is to force the bombers to fly high. There are two reasons for this

Low-flying bombers are practically immune from anti-aircraft fire. They approach so suddenly and pass so rapidly, that even machine guns cannot be trained on them quickly enough. Moreover, low-flying aircraft can drop their bombs with far more accuracy.

The barrage, therefore, by forcing the bombers above it, exposes them to anti-aircraft fire and makes their task of accurate bombing far more difficult.

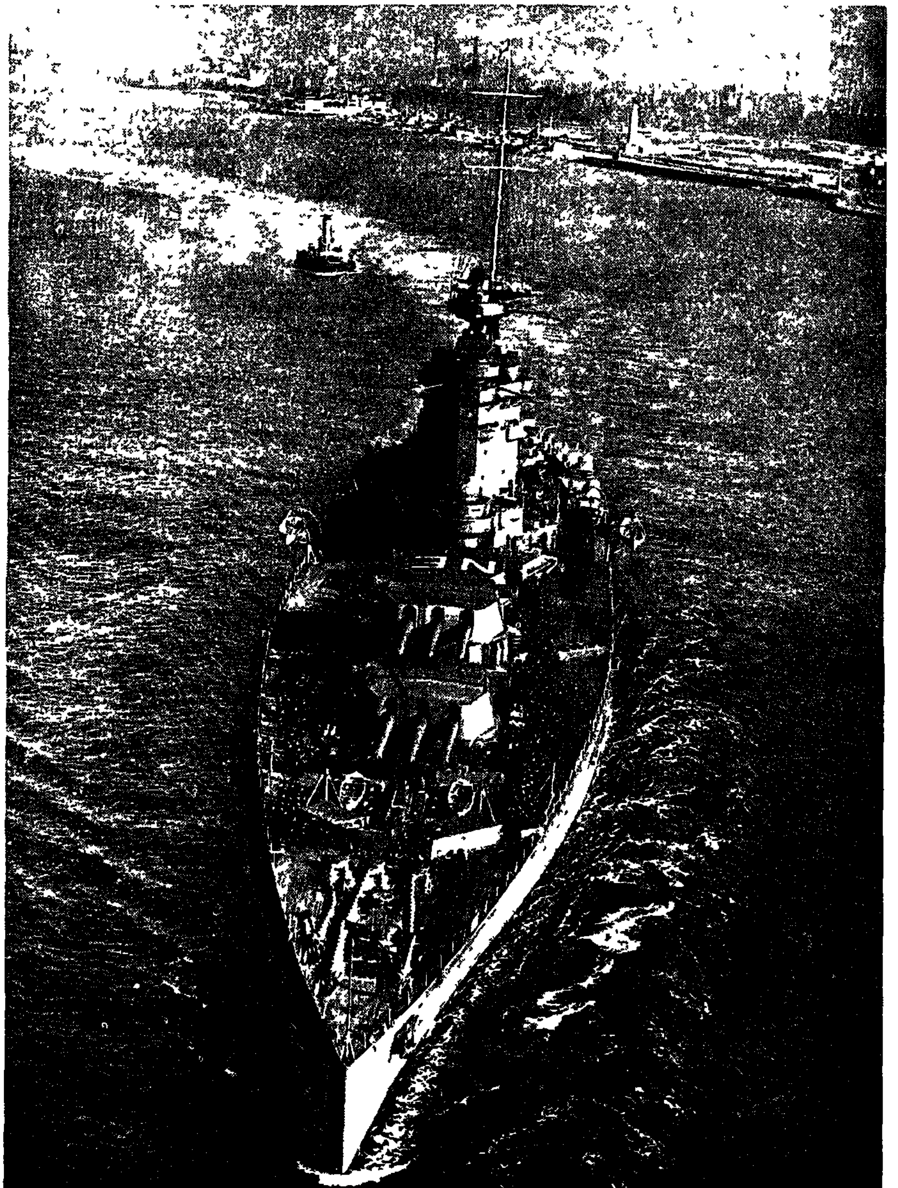
Each balloon is worked by a ground crew which is a self-contained unit. The balloon when deflated, is carried on the lorry which holds the winch, or a trailer that carries the hydrogen cylinders used to fill it. A balloon therefore can be rapidly moved from place to place.

### OPERATING THE WINCH

The lorry also carries a second engine operating the winch for the cable, to which the balloon is attached. Some skill is needed to operate these motors which bring the balloon down, and, as in an ordinary car, they are equipped with gears and clutches. To protect the man operating the winch in the event of the cable snapping and whipping dangerously, a wire cage encloses his seat.

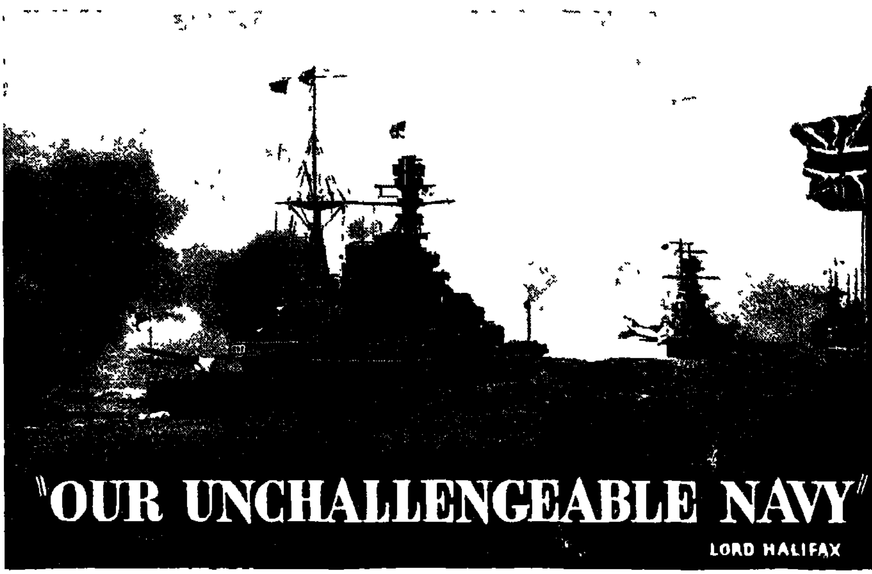
In emergencies the balloon can ascend very rapidly and can remain up for a considerable period. Periodically, however, it must be brought down for examination and to refill it with hydrogen, some of which is inevitably lost through leakage.

When a balloon is in the air, its cable does not lie directly below it but, due to the force of the wind, lies like the string of a kite (This fact, of course, makes it more difficult for an airman to avoid the cable.) The balloon is held head-on into the wind by the large fins at its rear. These fins are not filled with hydrogen, but in each is a hole which enables the wind to fill the fin and, therefore, to keep the balloon stable and head-on.



A MIGHTY CAPITAL SHIP LEAVES PORT

*H M S "Nelson," and her sister ship H M S "Rodney," are amongst the most powerful battleships in the world Both were launched in 1925 and mount nine 16-inch guns in triple turrets Each vessel cost seven and a half million pounds to build, and has a crew of 1,300 men Despite their great size (34,000 tons), the "Nelson" and the "Rodney" can steam at over twenty-three knots In places their armour plating is sixteen inches thick.*




*SECTION II*

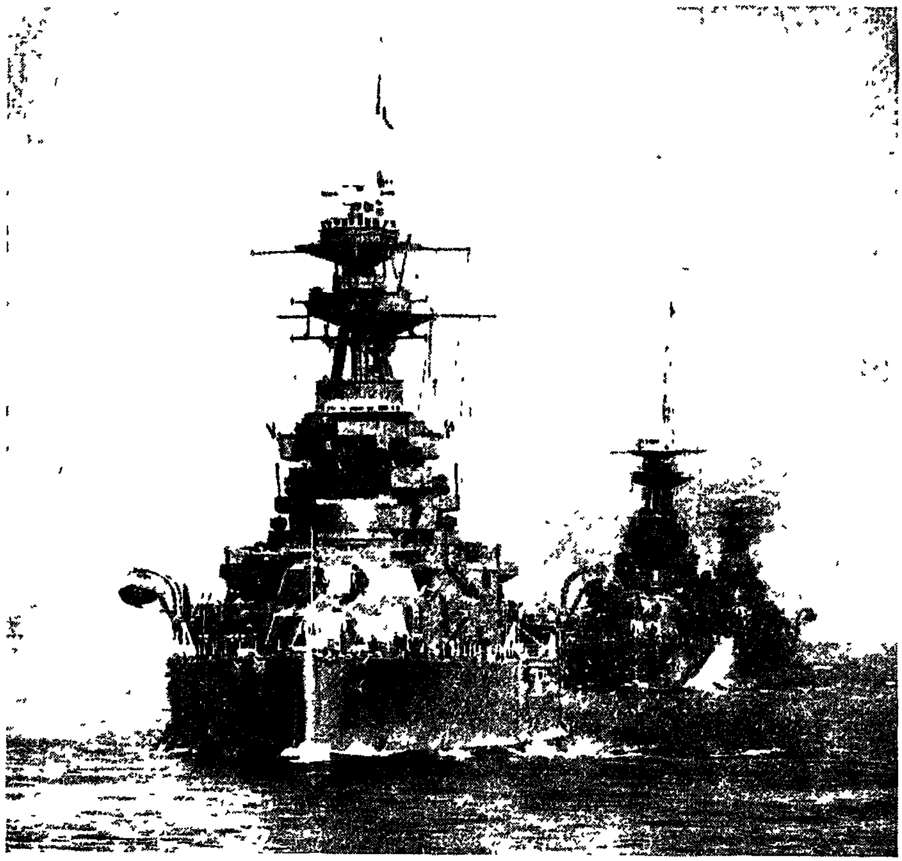
CHAPTER VI

# ORGANIZATION OF THE NAVY

THE Royal Navy through centuries of magnificent achievement, has well earned the title of "Britain's Sure Shield." This title is in no wit defamed by the advent of the aeroplane. No one can say what would happen if Britain's Air Force and Britain's Army were both defeated, but any one can say what would happen if Britain's Navy were defeated in a war—that war would be lost. In this sense of the word the Navy is paramount in Britain's defence. Mr. Winston Churchill crystallized this point of view most forcefully in his book *The World Crisis*, when he described Admiral Jellicoe, the then Commander-in-Chief of the Grand Fleet, as the only man who could lose the war in an afternoon. That description of the British naval commander-in-chief still remains true. The defeat of the British Navy would be identical with the defeat of Britain It is not difficult to find a reasonable explanation for this statement.

In the first place, Great Britain is an island, and an island that is not self-supporting. She is absolutely dependent in consequence on her sea-borne trade. She garners produce from the four corners of the earth, and ships it to her factories and to her citizens in the vessels of her merchant navy. The trade routes of the seven seas of the world must therefore always remain open to her, for unless they are open she can be starved into surrender.

In the second place, Great Britain is the focal point of a vast empire, the war effort of which is of the most vital importance. If that empire is to produce its greatest war effort, if the goods and the men from all its broad territories are to



BATTLESHIPS IN LINE AHEAD FORMATION

*The world's most powerful battleships and battle cruisers form the foundations of British naval supremacy The very fact that they exist immobilizes an enemy fleet Each of these ships may cost six or seven million pounds The main armaments are batteries of 14 5, 15 or 16-inch guns Heavy armour protects vital parts from shell, torpedo, mine and bomb*

be poured into a European struggle, then again, the shipping lanes of the world's oceans must be safe for British ships. Britain and her empire depend on the sea So long as the British Navy retains undisputed command of the seas, no enemy can enforce a blockade of Britain's coasts, no enemy can intercept the vital supply of men and materials that the Empire, and indeed the rest of the world, can place at her disposal.

The function of the British Navy, however, is by no means wholly defensive It protects Britain from the blockade, but because of its power it can enforce a blockade of the enemy. Continental powers cannot, for obvious reasons, be wholly blockaded from the sea, their land frontiers being immune from naval surveillance. None the less, European powers rely for a great part of their essential raw materials on seaborne trade. If that can be stopped, the structure of their economic life is very seriously disturbed. In these modern times when victory in war is more and

more a question of economic resources, the power of the blockade, between combatants otherwise more or less equally matched, is likely to be decisive.

The duties of the Royal Navy in wartime therefore, can be divided roughly into three groups.

1. The protection of the trade routes of the world's oceans

2 The blockade of the enemy's ports and coasts.

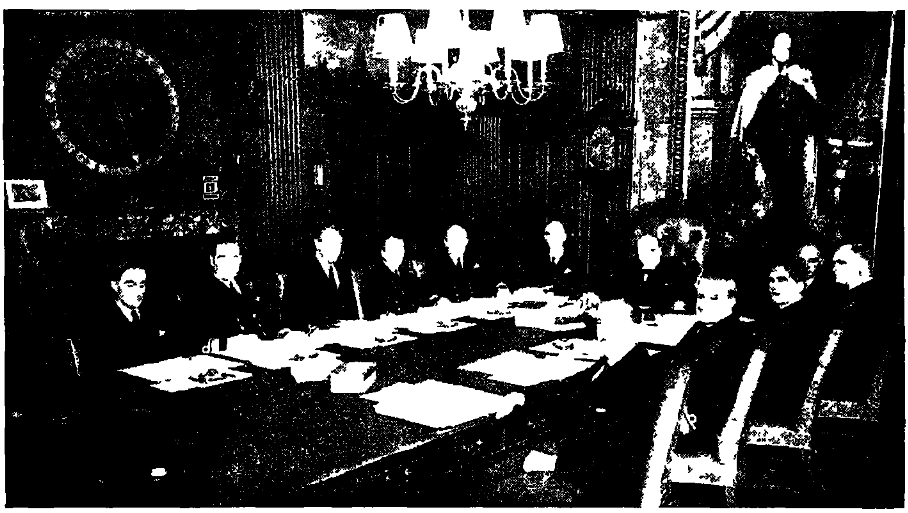
3. The defeat of the enemy fleet

When it is remembered that, as a consequence of these duties, the Royal Navy has to operate day and night during wartime, literally over millions of miles of ocean, some idea of the formidable nature of these duties can be gained.

Britain began the war in September, 1939, with the most powerful fleet in the world (Fig. 1). Although it had been reduced in size as a result of limitation treaties, to a point at which, in cruiser and destroyer strength, her minimum requirements were not reached, she had never seriously imperilled that command of the seas on which her very existence as a State rested Some interesting comparisons between the navies of Britain, France and Germany as they existed in September, 1939, are shown in Figs. 2, 3 and 4 on the following pages

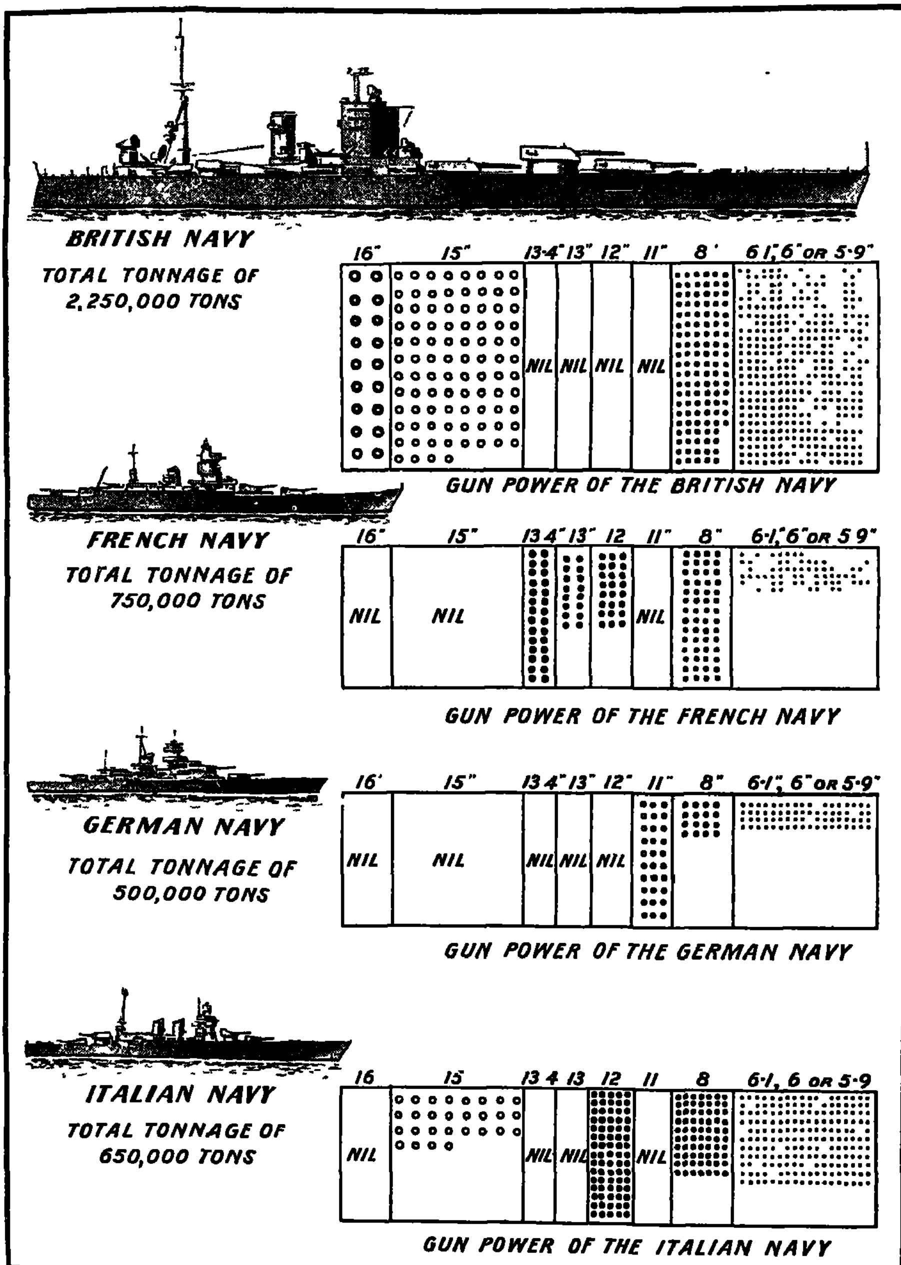
## OTHER NAVAL ASSETS

Fortunately, Britain also possessed on the outbreak of war, not only a magnificent fleet, but also unmatched facilities, in the form of shipyards and dockyards, for augmenting her navy and for maintaining it in a state of efficiency. In the



THE BOARD OF ADMIRALTY IN SESSION

*In this historic room at the Admiralty, London, all decisions affecting the Royal Navy are taken This picture shows the Board of Admiralty in session in March, 1940 The members, from left to right, are Mr Geoffrey Shakespeare, Parliamentary and Financial Secretary, Rear-Admiral H E Burrough, C B, Assistant Chief of Naval Staff, Vice-Admiral the Hon Sir Alexander R Ramsay, Fifth Sea Lord, Rear-Admiral T S V Phillips, Deputy Chief of Naval Staff, Admiral of the Fleet Sir Dudley Pound, First Sea Lord, Sir J Sidney Barnes, Deputy Secretary, Mr Winston S Churchill, First Lord, Sir Archibald Carter, Secretary of the Admiralty, Admiral Sir Charles Little, Second Sea Lord, Rear-Admiral B A Fraser, Third Sea Lord and Controller, Rear-Admiral G S Arbuthnot, Fourth Sea Lord, Captain A. U M Hudson, Civil Lord The secretary is the only permanent member of the board*




COMPARATIVE TONNAGE AND GUN POWER OF CHIEF EUROPEAN NAVIES

**Fig. 1.** *This diagram shows in round figures the comparative tonnage of the navies of four European nations on September 3, 1939 Tonnage building is not included The charts on the right-hand side show the comparative gun power of these navies*

man power of her far-flung empire, she possessed an almost limitless supply of fine seamen, whose courage and resourcefulness could never be questioned.

It will readily be appreciated that, because of the reasons outlined above, the Navy has always played the supreme part in the wars in which Britain has been engaged during the centuries since she has been a nation. Because of the traditions associated with this fact the Navy is rightly accorded first place amongst Britain's fighting forces, and proudly boasts the title of the Senior Service.

#### THE AEROPLANE AND THE NAVY

Neither has the aeroplane changed the position. The aeroplane has both complicated and simplified the work of the Navy. It has complicated its work because the Navy must now look for attack from the air as well as from the sea, the Navy—that is, in so far as it is concerned with the protection of merchant ships, or itself—must guard against the bomb as well as against the shell and the torpedo. It has simplified the work of the Navy because it has immeasurably extended the area over which the Navy can watch. One aeroplane in half an hour's flying in fine weather, can patrol an area of sea that five destroyers could only patrol in a day. This subject is referred to later in Chapter X.

To the organization of the Senior Service, literally centuries of experience have contributed, and today Britain is not only equipped with a fleet that is second to none in the world, but also has an organization behind that fleet that cannot be rivalled. To the layman it is inevitable that the British Navy should be thought of in terms first and foremost of fleets and ships. He hears little, and only indirectly, of the vast Governmental organization behind them, but a moment's reflection will show that without that organization the Navy could never function; and no one can understand the Navy who has not some idea of how it is organized and directed.

#### BOARD OF ADMIRALTY

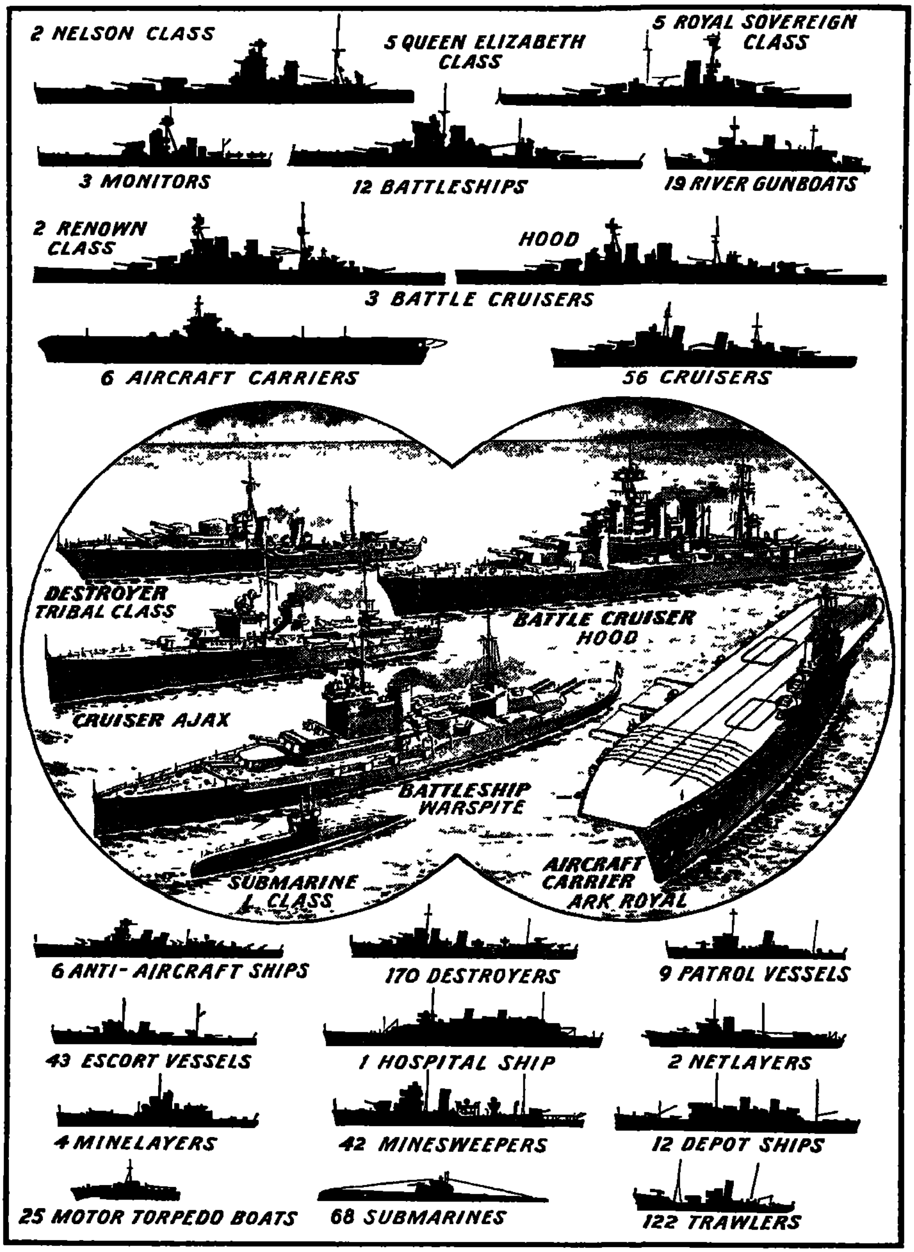
The supreme command of the Navy is vested in what is known as the Board of Admiralty On the outbreak of war in September, 1939, it comprised eleven members Seven of these were serving naval officers of high rank, three were political (or Parliamentary) members, and one was a Civil Servant. This last, known as the Permanent Secretary of the Admiralty, is the only permanent member of the Board of Admiralty His duties are very important. It is through him that the continuity of work is maintained, in spite of changes in the political and naval membership of the board. His staff not only carry out all the secretarial work of the Admiralty, but also keep all records of administration and the accounts for the whole Navy.

The three political members consist of the First Lord of the Admiralty, the Parliamentary and Financial Secretary of the Admiralty and the Civil Lord of the Admiralty. The seven naval appointments comprise the First, Second, Third, Fourth and Fifth Sea Lords, and in addition, appointed as assistants to the First Sea Lord, two other officers, a Deputy Chief of the Naval Staff and an Assistant Chief of the Naval Staff.

#### LINK WITH GOVERNMENT

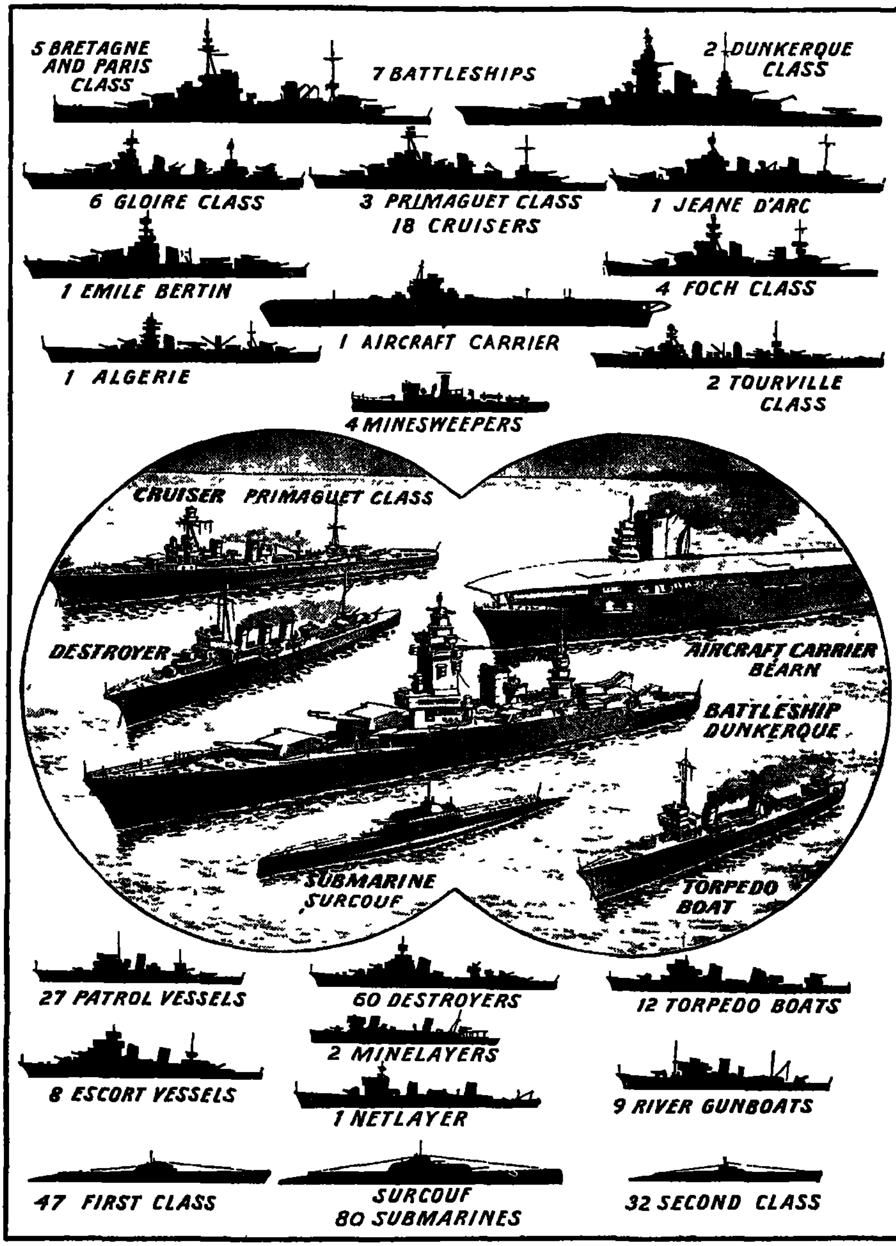
The link between the Admiralty and the Government is supplied by the First Lord of the Admiralty, who is always a member of the Cabinet. In peace time the three political members hold office only so long as their party is in power. They change, that is, when the administration of the day goes out of office, or they may be displaced at the discretion of the Prime Minister

The most important member of the



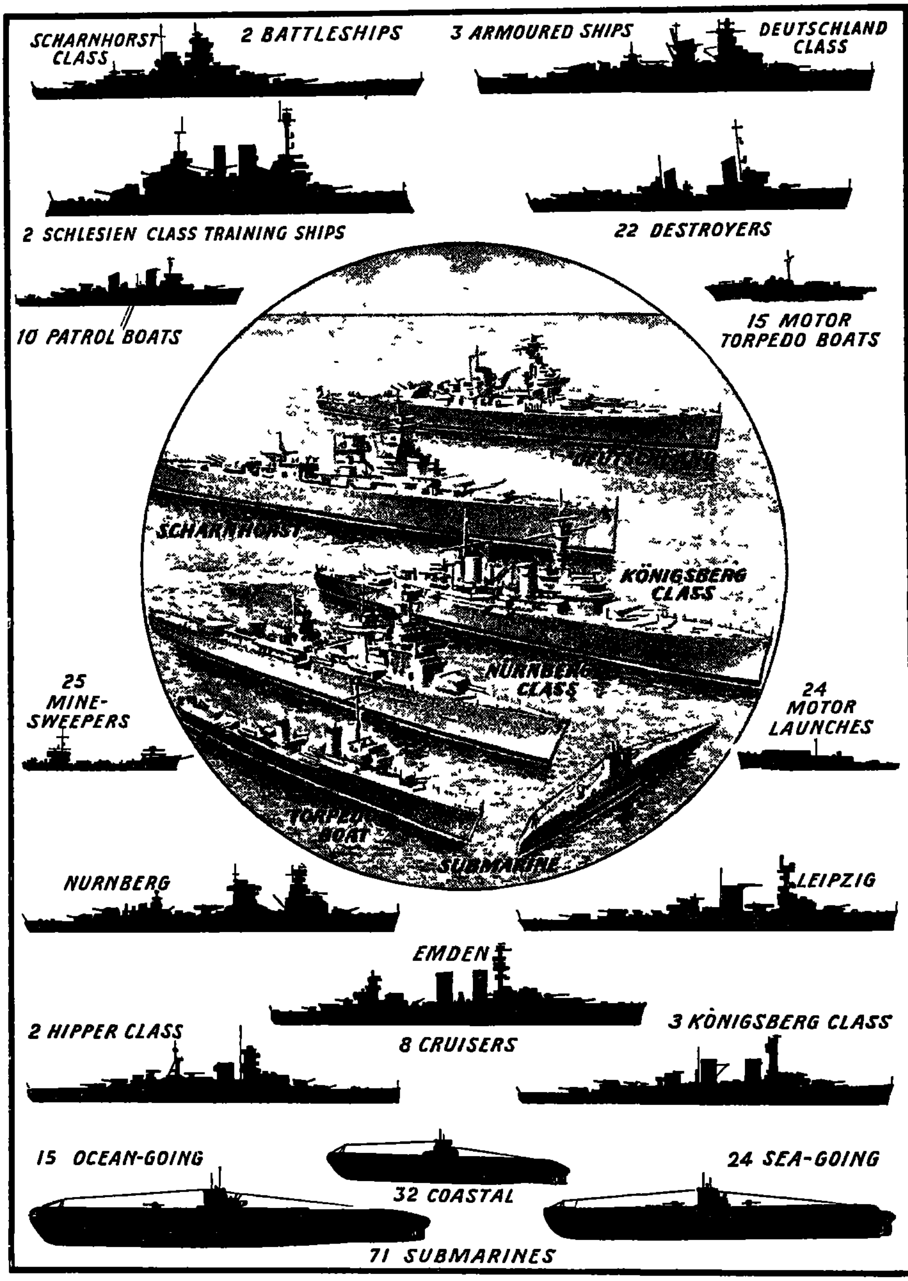

STRENGTH OF THE BRITISH NAVY

**Fig. 2.** *This picture affords an interesting comparison between the number and types of ships of the British Navy and those of France and Germany, seen in the two following illustrations. Only ships actually in being on September 3, 1939, are shown, tonnage building being disregarded Minor war vessels are not included*




STRENGTH OF THE FRENCH NAVY

**Fig. 3.** *Types and numbers of the principal war vessels in the French Navy as at September 3, 1939 This navy, although smaller than Britain's, is considerably larger than Germany's and includes some very fine modern ships The submarine "Surcouf" (see inset) is the largest in the world In submarines France is even stronger than Britain.*




STRENGTH OF THE GERMAN NAVY

**Fig. 4.** *Types and numbers of the principal ships of the German Navy as at September 3, 1939 At that date Germany had only three battleships carrying guns as large as eleven inches the "Deutschland," "Admiral Scheer" and "Admiral Graf Spee"*

Board of the Admiralty is undoubtedly the First Lord He may have little technical knowledge of naval matters, however, and invariably he has a rear-admiral appointed as his naval secretary. This rear-admiral acts in an advisory capacity The First Lord is head of the political side of the Admiralty and through him are derived the decisions made by the Government of the day with regard to general strategy and the use of the Navy as a whole

The First Sea Lord, however, is head of the technical side. He is, as already said, Chief of the Naval Staff (referred to below). It is important to remember this distinction between the First Lord of the Admiralty and the First Sea Lord, as the terms are sometimes confused

Each of the five Sea Lords is concerned with specific duties. These appointments are not permanent and are made always from the list of senior naval officers who, after a term of office at the Admiralty, return to active commands The constitution of the Board of Admiralty is shown diagrammatically in Fig. 5.

The Naval Staff consists of the five Sea Lords and the two assistants of the First Sea Lord, the D.C.N.S. and the A.C.N.S. Each of the Sea Lords is responsible for a particular aspect of the Navy's organization. The First Sea Lord is Chief of the Naval Staff and has two assistants to help him. The Second Sea Lord is Chief of Naval Personnel. The

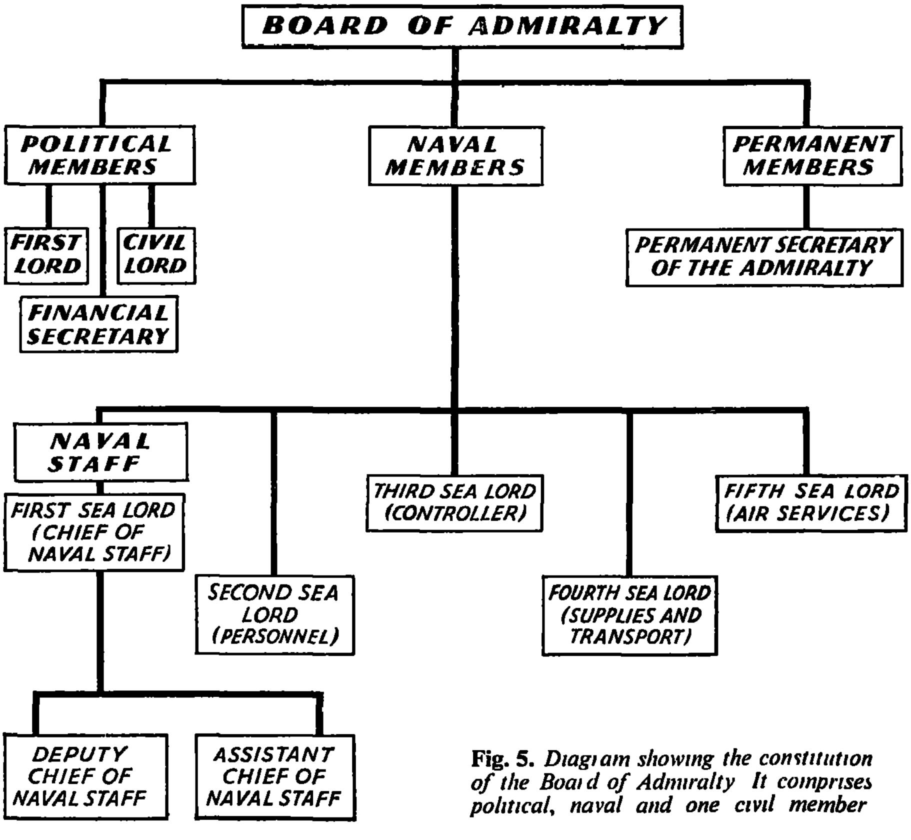



**Fig. 5.** *Diagram showing the constitution of the Board of Admiralty It comprises political, naval and one civil member*

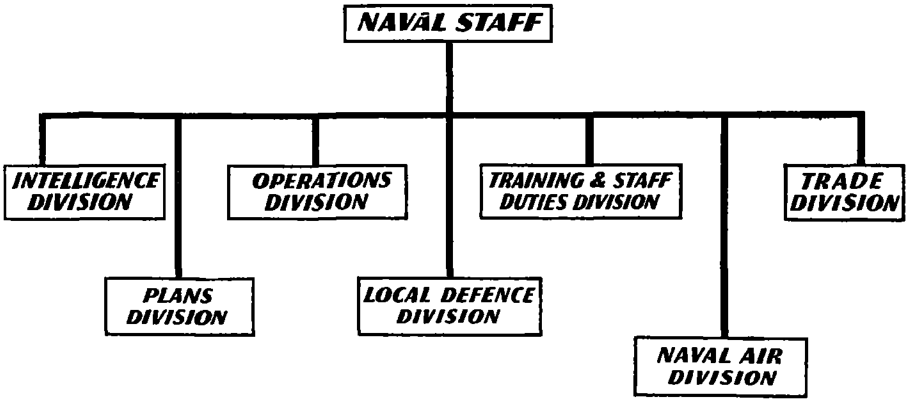



FIG. 6. *Diagram showing the principal divisions of the Naval Staff*

Third is Controller of the Navy. The Fourth is Chief of Supplies and Transport, and the Fifth Sea Lord is Chief of the Naval Air Services

#### DIVISION OF NAVAL STAFF

Even these divisions of the work and organization of the Navy are not sufficient. Below the Naval Staff, which really comprises the planning and advisory heads of the technical side, is an immensely complicated subsidiary organization that for simplicity is split up into a number of divisions. Each of these divisions is supervised by a naval officer of the rank of rear-admiral or captain. The Naval Staff is, of course, in control of all the divisions, but the work of the individual members of the staff may overlap from one division to another These divisions are shown diagrammatically in Fig. 6, and they are referred to below. Here we must add a note about the duties of the individual members of the Naval Staff.

The Chief of the Naval Personnel (the Second Sea Lord) is responsible for all matters concerning officers and ratings of the Navy, such as their promotion and welfare. The Controller of the Navy (Third Sea Lord) is responsible for the provision of ships, armaments, equipment, etc. The Chief of Supplies and Transport (the Fourth Sea Lord) is responsible for seeing that the Navy has all necessary stores, including food, fuel and water; that these stores are where they are wanted, and that transport is available to carry them. This work is particularly vital as it is imperative that the ships operating all over the world should find all necessary supplies and fuel available at any of the bases at which they may call. Their stocks must be replenished without delay. The Chief of the Naval Air Services (the Fifth Sea Lord) is, as his title suggests, responsible for the organization of the Fleet Air Arm. This work covers all aircraft carriers and shore air stations of the Navy.

The chief divisions into which the work of the Naval Staff is divided (Fig. 6) are :—

1. Naval Intelligence.
2. Plans.
3. Local Defence.
4. Trade.
5. Operations.
6. Training and staff duties.
7. Naval Air Division.

The first of these, Naval Intelligence, is concerned with the collection of information about naval matters from every part of the world. By the patient accumu-

lation of many apparently unrelated facts, gathered from every imaginable source, a comprehensive record of foreign naval activities is assembled.

The Plans Division is not concerned with the design of ships but with the planning of campaigns. Plans of action are drawn up for every conceivable eventuality, and are ready to be applied for any type of action that the enemy may initiate. Whenever an emergency occurs, the Plans Division is able to produce at once the agreed plan of action in respect of this emergency, the whole scheme being cut and dried in advance. No time is lost, therefore, in the laborious working out of the details

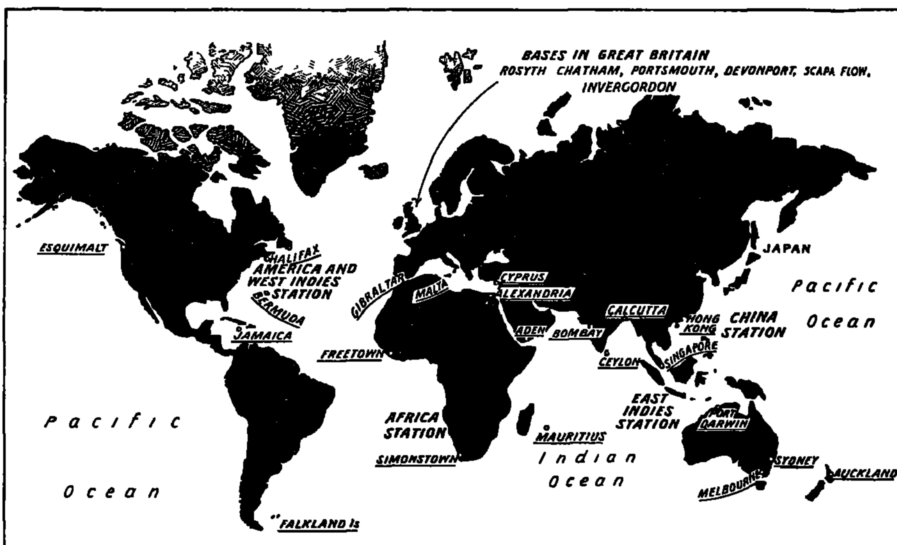
The Local Defence Division deals with the protection of bases and harbours from enemy attack. The Trade Division is concerned with the organization of convoys and similar measures for the safety of merchant shipping.

The Operations Division controls the movements of ships about the world and their mobilization for naval operations when enemy warships are located

### OTHER DIVISIONS

The Training and Staff Duties Division is concerned, as its title suggests, with the proper instruction and training of the naval personnel, and with the allocation of the duties that have to be undertaken.

The Naval Air Division is self-contained and its work is obvious from its title. In addition to these divisions of the Naval Staff, there are a number of departments of the Admiralty which




FOREIGN STATIONS AND NAVAL BASES OF THE BRITISH EMPIRE

**Fig. 7.** *This map illustrates the foreign stations maintained by Great Britain throughout the world They are the China Station, the American and West Indies Station, the East Indies Station, and the Africa Station Each station has a number of ships of various types attached to it, and each station forms a separate unit under its own commander-in-chief The fact that Great Britain has to maintain ships in so many parts of the world led to the establishment of naval bases These bases, underlined on the map, are carefully distributed so that naval vessels wherever they may be are within reach of a base for repairs, etc The bases are protected by land batteries, strong enough to repel almost any attack from the sea*

deal with specialized subjects of all kinds, ranging from compasses and victualling through naval construction to dockyards and scientific research.

### ADMIRALTY CONTROL

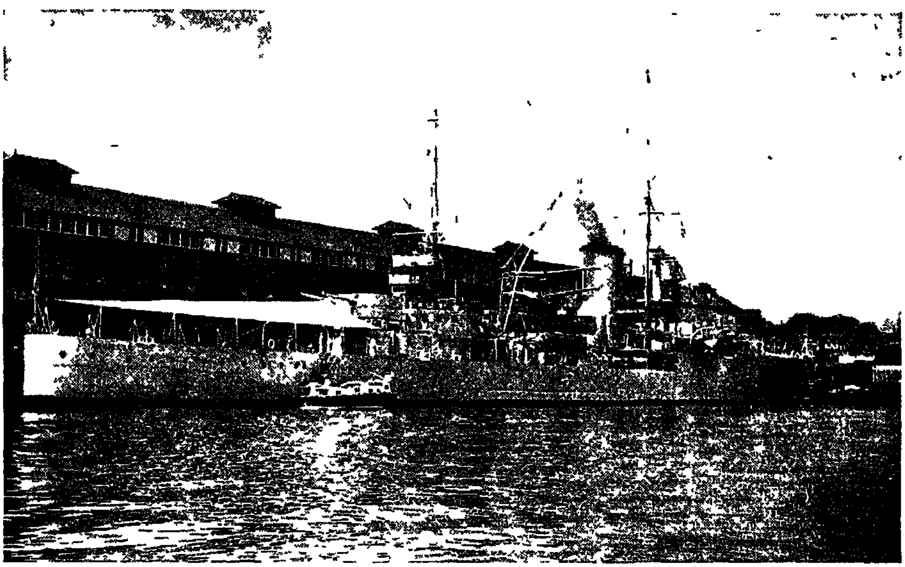
Having learnt something of the central administration of the Navy, let us turn to the hundreds of ships under the control of the Admiralty and learn how they are disposed throughout the world, divided into fleets, and provided with bases from which to operate Before we do this, however, it should be mentioned that every ship in the British Navy, no matter in what part of the world, is able to get into immediate contact with the Admiralty in London by means of wireless telegraphy should this be necessary As a result the Admiralty maintains the closest control of all naval movements

The ships of the British Navy are divided into a number of fleets and squadrons. There are two main fleets, the Home Fleet and the Mediterranean Fleet, and in peace time there is also a Reserve Fleet. In addition to these there are a number of squadrons attached to four foreign stations (Fig. 7). The largest is the China Station, the other three being, the American and West Indies Station, the East Indies Station and the Africa Station. Each of these foreign stations forms a separate unit under a commander-in-chief, like the main fleets

Besides these main fleets and foreign stations there are the navies of the Dominions. Of these the navy of New Zealand occupies a peculiar position It is in effect part of the British Navy, and is known as the New Zealand Division, but it is manned principally by New Zealanders, and during peace time its upkeep is paid for by New Zealand. The Royal Australian Navy is the largest of the Dominion navies and contains a number

ON THE CHINA STATION

*The British cruiser H M S "Carlisle" off the Shanghai Bund The China Station is the largest of the Navy's four foreign stations Fig 7 shows the disposition of these stations*



NEW ZEALAND'S HEROIC CONTRIBUTION TO THE WAR EFFORT

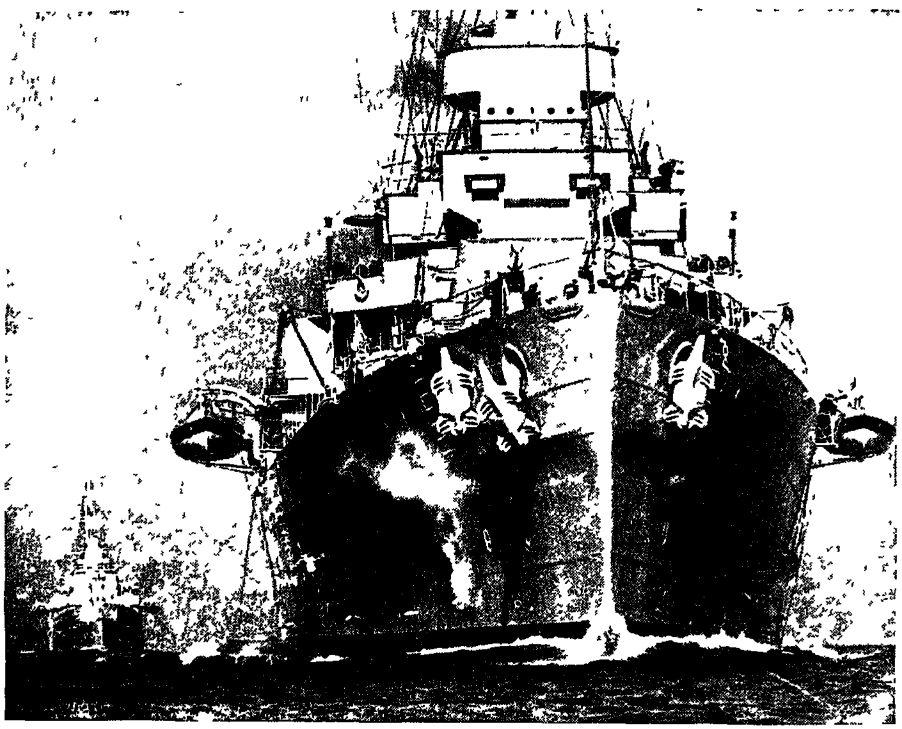
*H M S "Achilles," one of the three cruisers that took part in the Battle of the Plate, belonged to the New Zealand Division of the British Navy This division is manned principally by New Zealanders, and during peace time its upkeep is paid for by the Dominion*

of cruisers, destroyers and escort vessels. The Royal Canadian Navy and the Royal Indian Navy are smaller. The latter is manned by subjects of the Indian Empire though a proportion of the officers are European The Royal Indian Navy as it is now developing, will gradually include more and more Indian officers.

Fleets, such as the Home Fleet or the Mediterranean Fleet, consist of squadrons of different types of warships, from battleships downwards. A squadron of warships does not necessarily indicate any special number of ships. In a squadron, for example, there may be only two or three ships, as is the case with the battle-cruiser squadron that, at full strength, consists of H.M.S *Hood*, H.M.S *Repulse* and H.M.S. *Renown*. On the other hand, a squadron of battleships or cruisers may comprise any number of ships, though four, six, or occasionally eight are the normal limits. Whether in peace time or in wartime the majority of ships with the Home Fleet and the Mediterranean Fleet, as on the four foreign stations, are fully manned and commissioned. The Reserve Fleet, however, is only partly manned during peace time, and it is from this fleet that the other fleets and stations draw any vessels required to maintain or augment their strength in emergency. The Reserve Fleet can be mobilized at very short notice and in point of fact most of it was fully manned and in active service along with the ships of the other fleets some weeks before the outbreak of war on September 3, 1939.

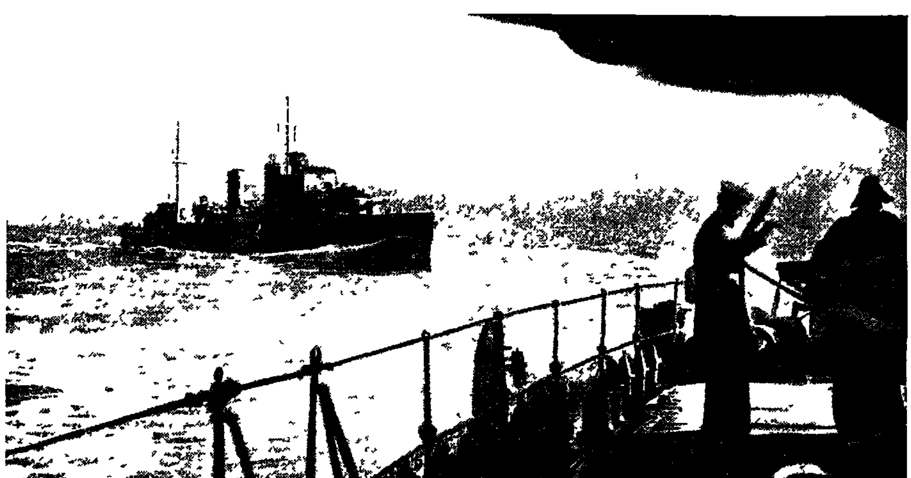
## NAVAL PORTS

A word must be added about the ports from which ships are commissioned. Home ports must be distinguished from naval bases, which are dealt with below The three main home ports are Chatham, Plymouth and Portsmouth, and the man power of the various ships in commission is drawn from these ports



AUSTRALIA HAS A NAVY TO BE RECKONED WITH

*Most of Britain's Dominions maintain their own navies This powerful cruiser, H M A S "Canberra," is the flagship of the Australian Navy, the largest of the Dominion navies.*



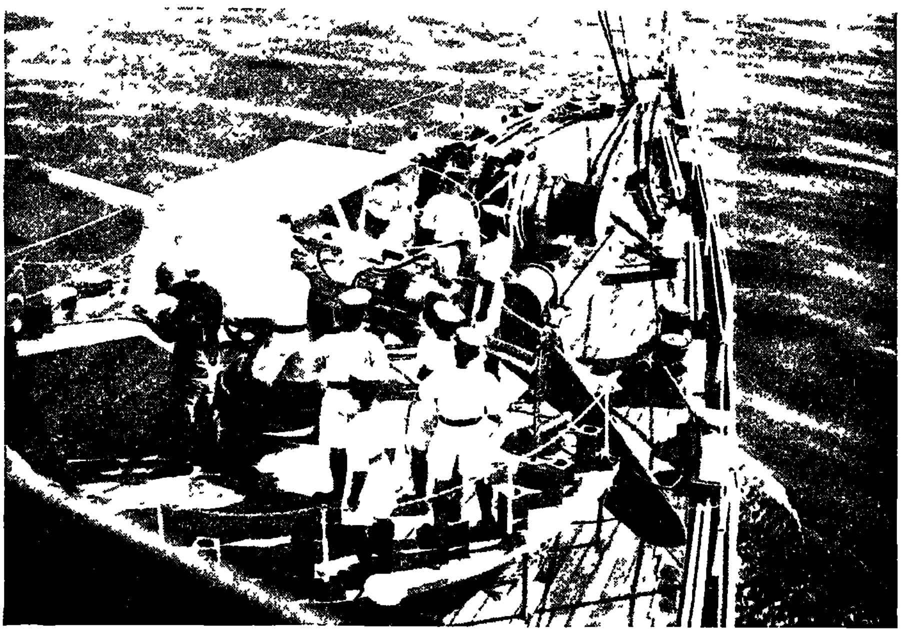
A SENTINEL FOR CANADA'S COASTS

*One of the destroyers of the Royal Canadian Navy Canada's small navy is extremely efficient Its main duty is to patrol the Dominion's coastline to protect shipping.*

so that they constitute the depots of the Navy when ships are in British waters

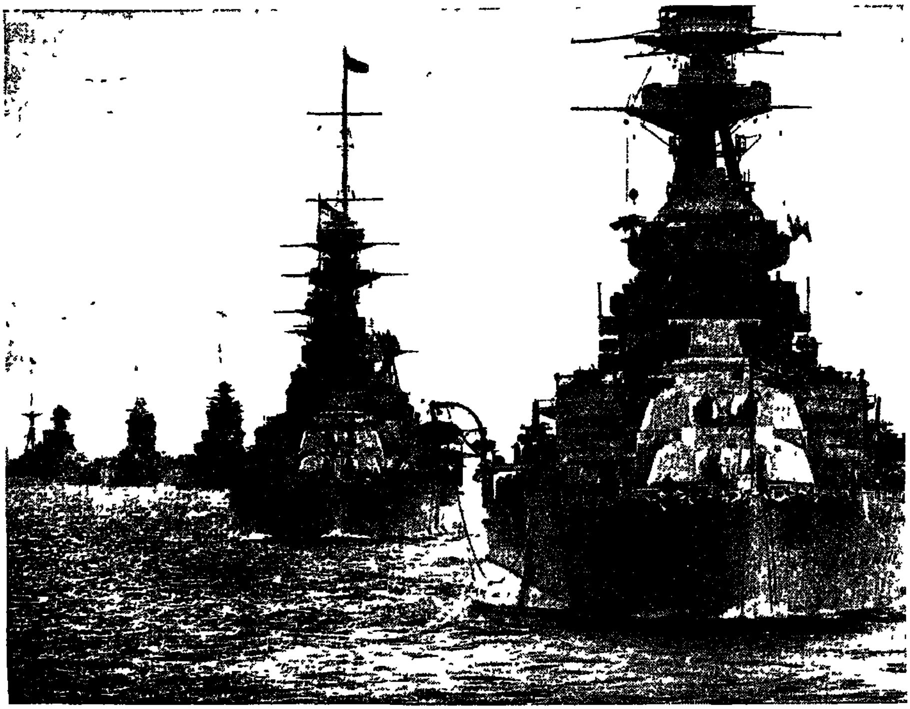
Naval bases are quite different, however, and exist to provide the various ships comprised in a fleet with facilities for repair and with supplies of fuel, ammunition, and essential stores. Fleets cannot remain at sea indefinitely, and sooner or later must return to a base. Because of the far-flung nature of its naval commitments, the British Empire has to maintain naval bases in almost every part of the world. If ships of the British Navy, for example, were engaged in war in the South Indian Ocean it would be impossible for them to return to Britain every time they required repairs, overhaul, revictualling or refuelling These naval bases therefore are carefully distributed geographically. Since the completion of the new naval base at Singapore there is now no part of the world in which the British Navy might be called upon to operate that is not within reach of a naval base. These bases are of vital importance, and their proper protection is a matter of great concern.

It might be imagined that naval bases are protected by the warships that use them. This is not so, for warships are required at sea, not as floating batteries to defend the land The bases are, in fact, protected from local attack by their own batteries. Land batteries of heavy guns always have a great advantage over ships. Because they are fixed to a given point and do not have to be carried about they can be much more heavily armoured and protected than the gun turrets of war ships. Moreover, since space is of less importance, the machinery for their operation can be more elaborate and their rate of fire in consequence can be



INDIA MANS HER NAVAL GUNS

*The Royal Indian Navy was formerly the Royal Indian Marine It is manned by Indians, with a proportion of white officers. These, however, are being replaced by Indian officers*



FIVE OF BRITAIN'S MIGHTY BATTLESHIPS

*Britain's great sea tradition is aptly illustrated by the names of three of these battleships, "Ramillies," "Revenge," "Nelson," "Rodney" and "Barham" On September 3, 1939, there were fifteen battleships and battle cruisers in the Navy The torpedo bulge of H M S "Ramillies" (in the foreground) can be clearly seen She is armed with eight 15-inch guns*

improved. Finally, since they are not floating, the problem of aiming their guns is very much simplified, and in addition range finding can be much more accurate. As a general rule, unless a warship attacking a land battery is equipped with guns of much greater range than those possessed by the battery, it will get the worst of the engagement.

### ANTI-AIRCRAFT MEASURES

Nowadays, of course, it is also necessary to protect naval bases against air attack, and this protection is afforded not only by anti-aircraft guns but also by shore-based aircraft. The distribution of the chief British naval bases throughout the world is shown in Fig. 7, page 177

We have now explained something of the organization of the Navy and of the way in which it is divided into fleets We have learned, too, something of the bases from which these fleets operate Let us now turn to the various types of ships that comprise the Royal Navy.

The effect of the naval agreements entered into between the naval powers since the end of the war of 1914-18, has been to limit the size of, and gun calibre of, different types of ships, and also to regulate the number and type of ships that a country might build. This effect has had the result of grouping the warships of all nations into certain well-defined classes, such as battleships, cruisers, destroyers and aircraft carriers.

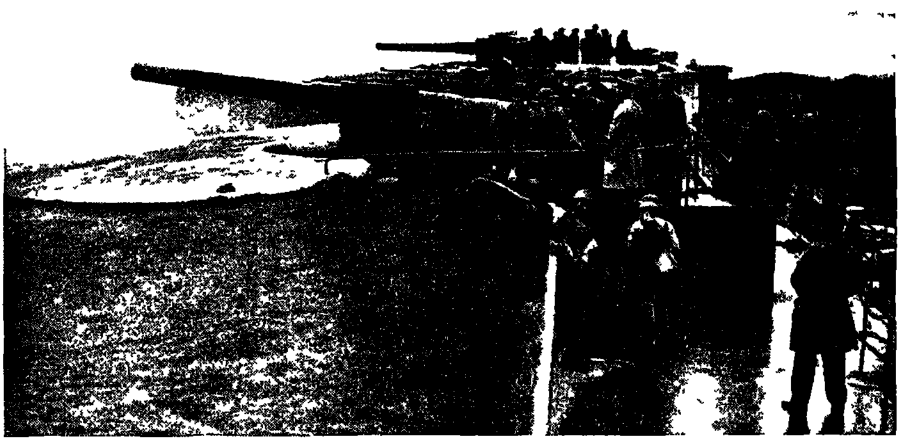
But variations between the sizes and armaments of the vessels falling into any one class can be quite considerable. Also, it cannot be assumed that ships in one class perform certain set duties, and that vessels in other classes never carry out this particular type of work. None the less, despite overlapping of duties, a broad division of ships in terms of their functions is possible. This division is as follows battleships, cruisers, aircraft carriers, destroyers, submarines and miscellaneous vessels. These types do not, of course, indicate all the types of ships in the Navy, for actually there are many more distinct groups, excluding the auxiliary ships and the less important of the smaller ships.

The battleship, alternatively known as the capital ship, is the vessel on which the ultimate decision in a big naval engagement depends. It is therefore the deciding factor in the assessment of the strength of opposing navies. Battleship meeting battleship is a struggle between the most powerful ships that either side can build. Therefore, the main function of British battleships is to defeat the battleships of the enemy.

For many years a heated controversy has raged not so much in technical as in lay circles, as to whether the battleship has been rendered obsolete by the bomber. Though the battleship presents a large target from the air, it is armoured against heavy shells more deadly than most bombs, and despite its size can never be an easy object to hit from the air.

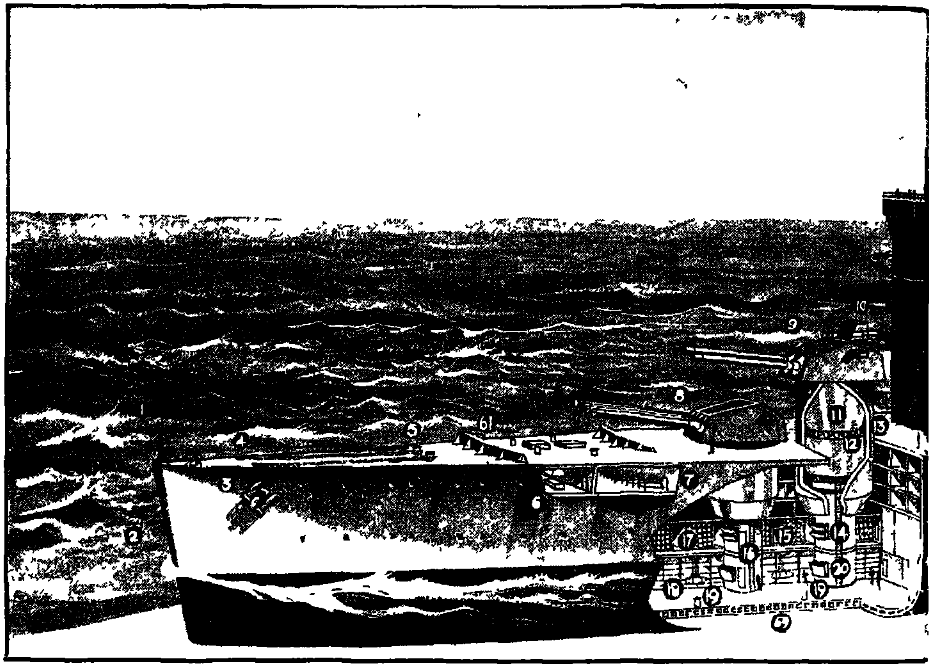
### BATTLESHIP CONSTRUCTION

Some light on this controversy is shed by the fact that the experts of all the great naval powers of the world continue to design battleships and those powers continue to build them. At the outbreak of war in September, 1939, the British Empire, for example, had no less than nine new battleships building. It is, indeed, the considered opinion of the British Government that the advent of



A COASTAL BATTERY TO DEFEND A PORT

*Britain's coasts and naval bases are defended by powerful coastal batteries manned by the Royal Artillery In a duel between warships and coastal batteries, the advantage, other things being equal, would always lie with the latter, for their aim can be more accurate*



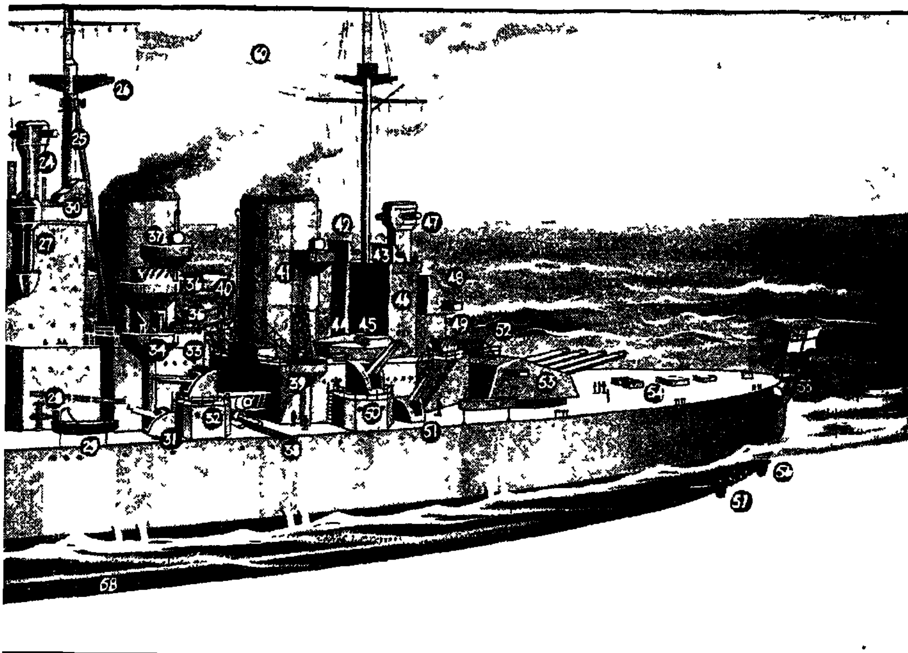
DETAIL OF A NEW BRITISH BATTLESHIP—

**Fig. 8.** *1, Jack staff. 2, Raked bows 3, Port anchor 4, Hawse holes for starboard anchors 5, Capstans 6, Operating theatre 7, Hospital 8, "A" turret four 14-inch guns 9, "B" turret two 14-inch guns 10, Multiple pom-poms 11, Working chamber 12, Turret rollers 13, Fifteen inches thick armour 14, Cordite tray 15, Magazine 16, Main ammunition supply shaft 17, Handling room 18, Shell room 19, Flooding valves 20, Shell tray 21, Control tower and bridge structure 22, Navigating bridge 23, Main director tower 24, Main fire control top 25, Tripod mast 26, Signal halyard 27, Torpedo director tower 28, Paravane 29, Twenty-five-foot whaler 30, Secondary armament director tower 31 and 32, Forward*

bombing aircraft has merely complicated the task of the naval architect. The aeroplane has not rendered the battleship obsolete, but the naval architect is now faced with the necessity of providing protection for a battleship from the air as well as from the water In consequence the anti-aircraft defences of modern battleships play a prominent part in their design.

A battleship (Fig. 8) is an extremely costly weapon of war. Seven or eight million pounds is frequently spent on building it and when it is remembered that a few well-placed torpedoes may end a battleship's career, the wisdom of continuing to build such weapons may be queried. Battleships, however, are essential to any naval power so long as a potential enemy also has battleships. Every class of ship smaller than a battleship finds its counter in the class above it. Torpedo boats are countered by destroyers, destroyers by cruisers, and cruisers in turn by battleships. The battleship, however, is the last court of appeal. It remains the rock on which the rest of the fleet is based. In consequence, an immense amount of thought is given to the design of battleships.

The effect of various naval treaties limiting the total tonnage of navies and



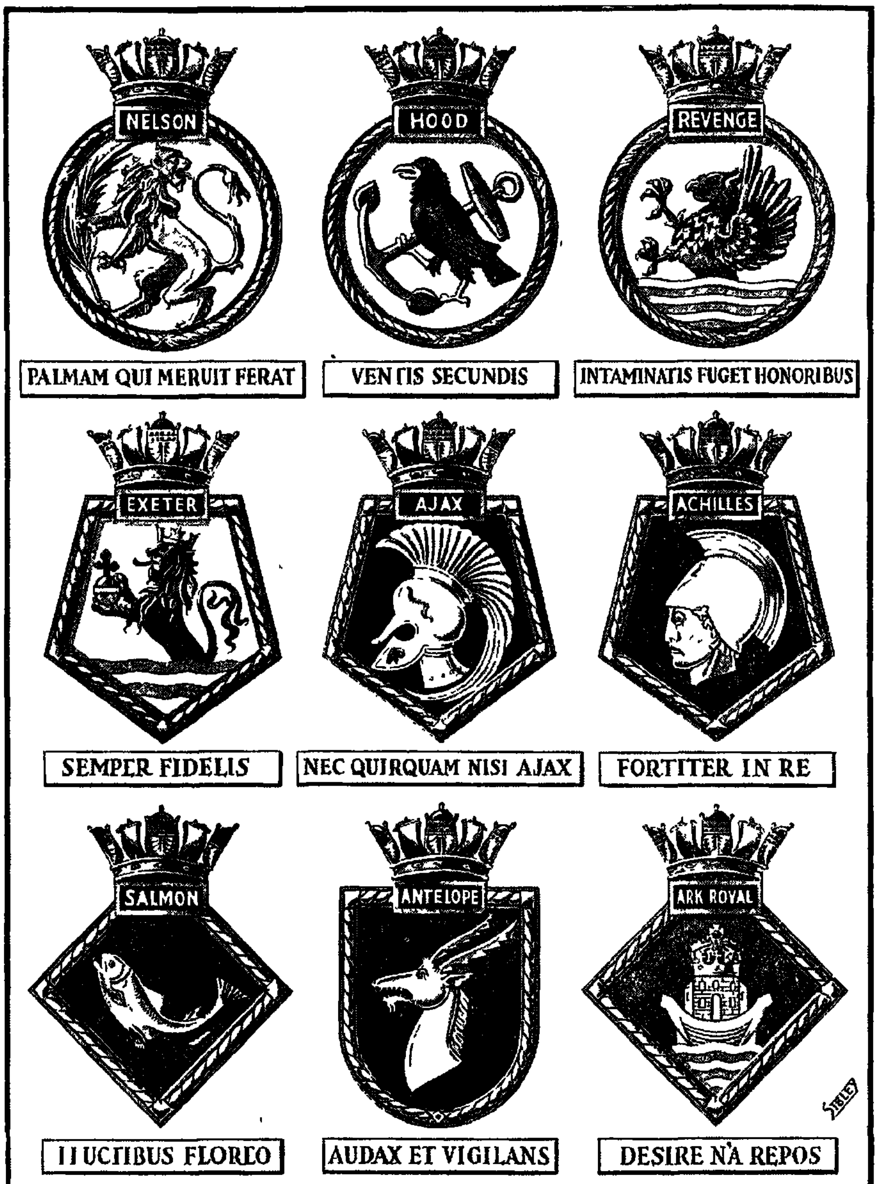
H M S "KING GEORGE V"

*port 5 25-inch secondary armament 33, Port aircraft hangar 34, High-angle gun 35, Carley floats 36, Multiple pom-poms 37, Forward port searchlight 38, Athwartship aircraft catapult 39 and 40, Aircraft and boat crane 41, Aft port searchlight 42 and 43, Secondary armament director tower 44, Shore boat 45, Admiral's barge 46, Aft control tower 47, Aft fire control top 48, Aft main director tower 49, Multiple pom-poms 50 and 51, Aft port 5 25-inch secondary armament 52, Multiple pom-poms 53, "X" turret four 14-inch guns 54, Quarter deck 55, Admiral's stern walk 56, Port inner propeller 57, Port outer propeller 58, Bilge keel 59, Double bottom 60, Wireless aerials 61, Breakwater*

the size of new ships, has been to call for increasing ingenuity on the part of their designers Naval architects are faced with the problem of providing for three irreconcilable necessities

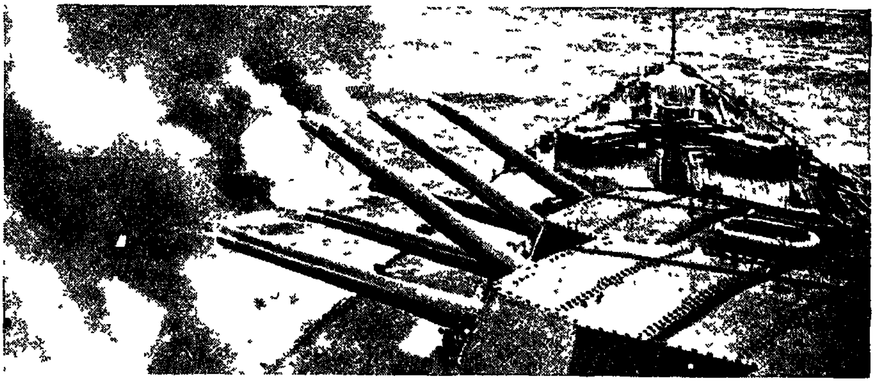
The battleship must be armed with the biggest and most powerful guns possible It must be protected with the heaviest weight of armour possible, and it must have the greatest speed possible. Big guns and armour plating are enormously heavy. The heavier the ship, the more powerful its engines must be if it is to travel fast through the water. The more powerful the engines, the more space they occupy This is a great problem.

It would seem, therefore, that in order to satisfy these three necessities, battleships must inevitably get bigger and bigger Naval treaties, however, have limited their tonnage at various times—a typical limitation figure being 35,000 tons—but their size is also limited by other factors. Battleships, for example, must use docks and harbours. If they outgrow existing docks and harbours, then new docks and harbours must be built. For this reason the tonnage of battleships must be limited to that with which existing dock facilities can deal. Battleships may be required to pass through canals in order to save detours of thousands




SYMBOLS OF NAVAL TRADITION—SOME SHIPS' BADGES

*Many of the ships in the British Navy bear names rich in honour Some, like the "Revenge," are lineal descendants of ships that fought against the Armada Others are named after famous admirals or historic cities Each ship bears the battle honours of her predecessors, and her badge generally indicates the origin of her name Explanations of the badges shown in this drawing are given on the opposite page*



NAVY'S MOST POWERFUL GUNS

*The nine 16-inch guns of H M S "Rodney" all firing together This is called a triple salvo All British battleships mount 14, 15 or 16-inch guns in heavily armoured turrets*

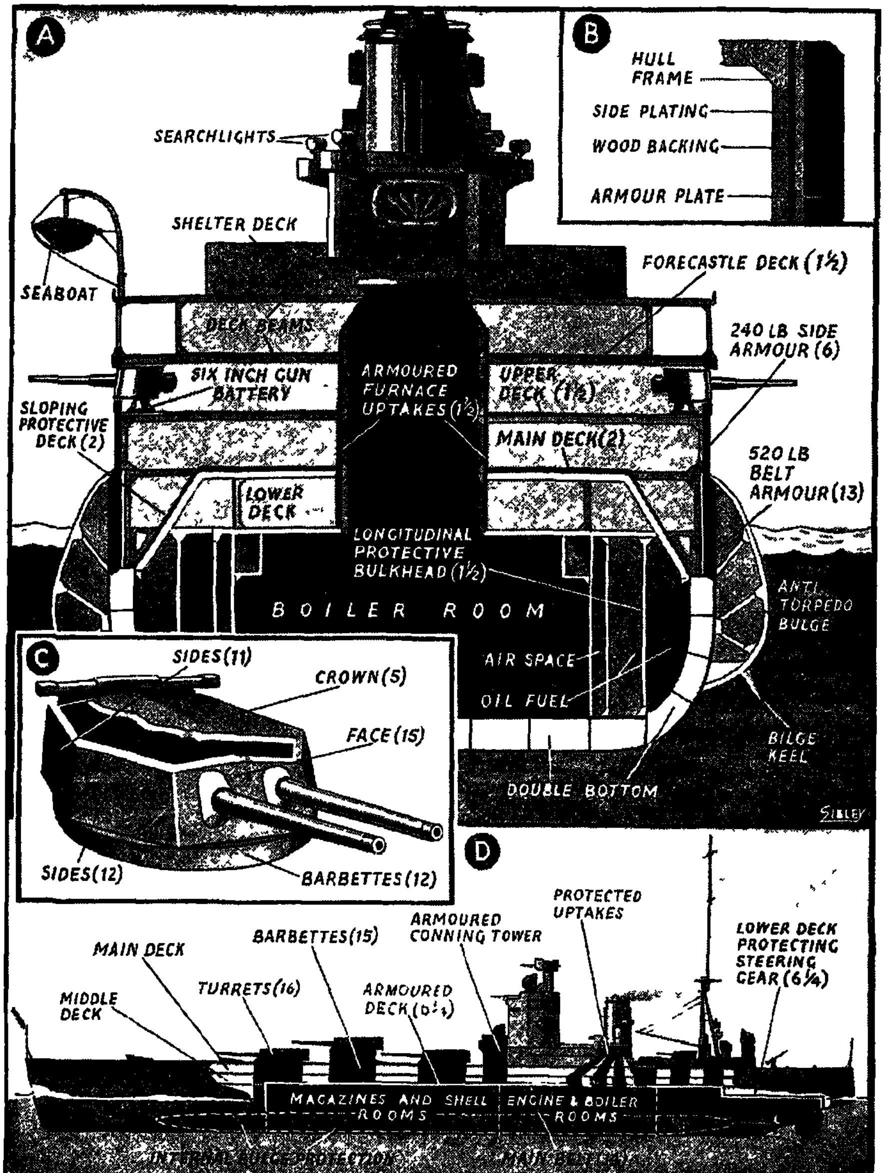
of miles. Again the width and depth of the canals will limit the size

Naval architects, therefore, are compelled to compromise. The more armour a ship carries, the smaller her guns will be, and the slower she will go. The fast-steaming vessels must necessarily be lightly armoured. These points are referred to again in discussing the construction of the vaunted German "pocket battleships" (*see* Chapter VII).

Whatever design is eventually chosen, however, a battleship must be the best protected of any ship in the fleet, and must also have the most powerful guns Because the weight of armour in a battleship is limited, it is therefore distributed to the best advantage It is heaviest, in fact, over the most vulnerable parts of the ship, such as the magazines, the trunks connecting them with the guns, the boilers and the engines. These vital parts are grouped together as closely as possible and are surrounded by especially thick armour, known as the main armour belt The vital area is also

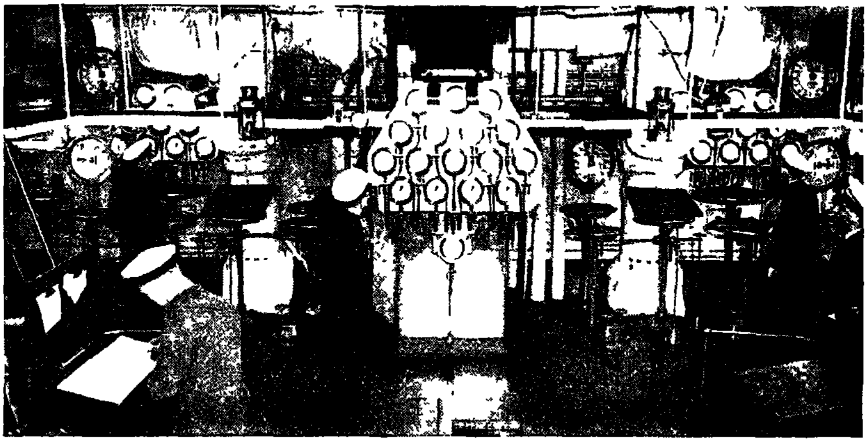
| Name Date of first ship | Translation of Motto | No of ships of name | Remarks |
|---|---|---|---|
| NELSON (1799) Battleship | Let him who has deserved it, bear the helm | 8th | Fleet Flagship |
| HOOD (1849) Battle cruiser | With fair winds | 3rd | Largest capital ship in the world Flagship of Battle Cruiser Force Badge—Crest of Admiral Viscount Hood (1724-1816) |
| REVENGE (1575) Battleship | He shines with untarnished honour | 10th | Battle honours – 1588, Armada 1591, Flores in the Azores 1759, Quiberon Bay 1805, Trafalgar 1916, Jutland Badge -Crest of Sir Richard Grenville |
| EXETER (1680) Cruiser | Always faithful | 5th | Badge—Arms of Town of Exeter Battle honours—1939, The Plate |
| AJAX (1767) Cruiser | None but Ajax can overcome Ajax | 8th | Battle honours—1780, St Vincent 1782, The Saintes 1801, Alexandria 1805, Trafalgar 1916, Jutland 1939, The Plate |
| ACHILLES (1744) Cruiser | Bravely in action | 9th | Battle honours—1805, Trafalgar 1939, The Plate |
| SALMON (1895) Submarine | I flourish in the waves | 3rd | Sank German cruiser, "Leipzig" Damaged German cruiser, "Bluoher" |
| ANTELOPE (1546) Destroyer | Bold and watchful | 13th | Sank two U-boats in one day Battle honours—1588, Armada. 1665, Lowestoft 1666, St James's Fight. |
| ARK ROYAL (1587) Aircraft carrier | Desire rests not | 3rd | Battle honours—1588, Armada (Flagship of Howard of Effingham) 1915, Dardanelles |

*A key to the ships' badges shown on the opposite page.*




ARMOUR PROTECTION OF A BATTLESHIP

**Fig. 9.** *Detail of the armour plating carried by a modern battleship The figures in brackets denote the thickness in inches of the armour plate Note the anti-torpedo bulge which takes the force of the explosion in the event of the ship being struck In most modern ships this bulge is internal, and does not interfere with the ship's normal lines* (A) *Cross section amidships of battleship of the "Royal Sovereign" class* (B) *Armour plate mounting* (C) *Armoured gun turret of H.M.S "Hood"* (D) *Armour of H M S "Nelson"*



ENGINE ROOM OF A BRITISH BATTLESHIP
*This view shows (centre) the control panel On the left and right can be seen the port and starboard telegraphs which repeat signals from the bridge*

given a specially armoured roof. The main armour may consist of steel plates fourteen inches thick. These plates are made so that their outer surface is specially hardened but their inner surface is softer. This softer inner surface provides an elastic backing for the whole and prevents the plates cracking under heavy bombardment.

Any vital areas of the ship, such as the control centres and the gun turrets, which must project above the main armoured belt, are also given an extra protection of specially heavy armour plating.

The general distribution of the armour plating in a battleship can be seen in Fig. 9.

The hulls of battleships are also protected by anti-torpedo bulges (dealt with more fully in Chapter IX).

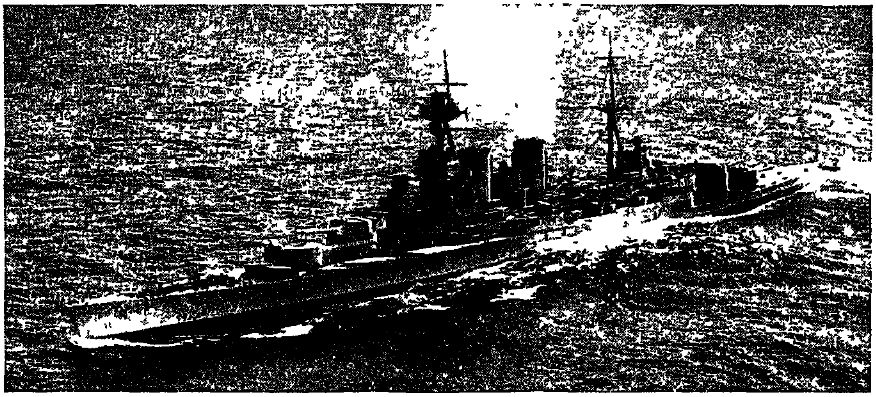
The weakest part of a battleship is the keel. It is almost impossible properly to protect this area. and it is practically never necessary. All British capital ships are heavily protected as well as magnificently armed. This is true not only of the capital ships she possessed at the outbreak of war, but even more of the new battleships she was then building.

After the battleship the battle cruiser comes next in importance. Actually this category of ship is almost extinct, but it originally implied a capital ship, armed with guns as heavy as those found in a battleship, but designed for higher speed, and in consequence more lightly armoured. Because of their speed they could enable a fleet to get to grips with enemy ships, seeking to avoid an engagement for strategic reasons.

**BRITAIN'S BATTLE CRUISERS**

The distinction between battleships and battle cruisers has almost disappeared as a result of improvements in the design of engines and boilers. Battleships today are capable of relatively high speeds.

Britain possessed at the outbreak of war three battle cruisers, H.M.S. *Repulse*, H.M.S. *Renown* and H.M.S. *Hood*. In H.M.S. *Hood* (Fig. 10) Britain had the most powerful battle cruiser in the world armed with eight 15-inch guns as well as a powerful secondary armament and capable of a speed of thirty-one knots despite her displacement of 42,100 tons. She was possibly the most powerful



H M S "HOOD," WORLD'S LARGEST WARSHIP

**Fig. 10.** *H M S "Hood," with a displacement of 42,000 tons, is the world's largest warship She is a battle cruiser and not a battleship Despite her size and her heavy main armament (eight 15-inch guns), she is a fast ship and can travel at a speed of thirty-two knots*

vessel of war in the world at the time and for all practical purposes may be classed as a fast battleship Extensive reconstruction has materially increased the defensive qualities of the *Renown* and *Repulse*

Next in rank to the battle cruiser is the cruiser, also a relatively well-armed ship, but one in which the armour, like the guns, is lighter than that of the battleship Cruisers, however, vary in size considerably, and between the largest and the smallest there may be immense differences in speed, guns, and protection. Here again, treaty limitation has affected design. The displacement of the largest British cruiser does not exceed 10,000 tons, and it has a main armament of 8-inch guns. Cruiser speeds are very high, however, approaching thirty-three knots in some cases A typical British cruiser is seen in Fig. 11

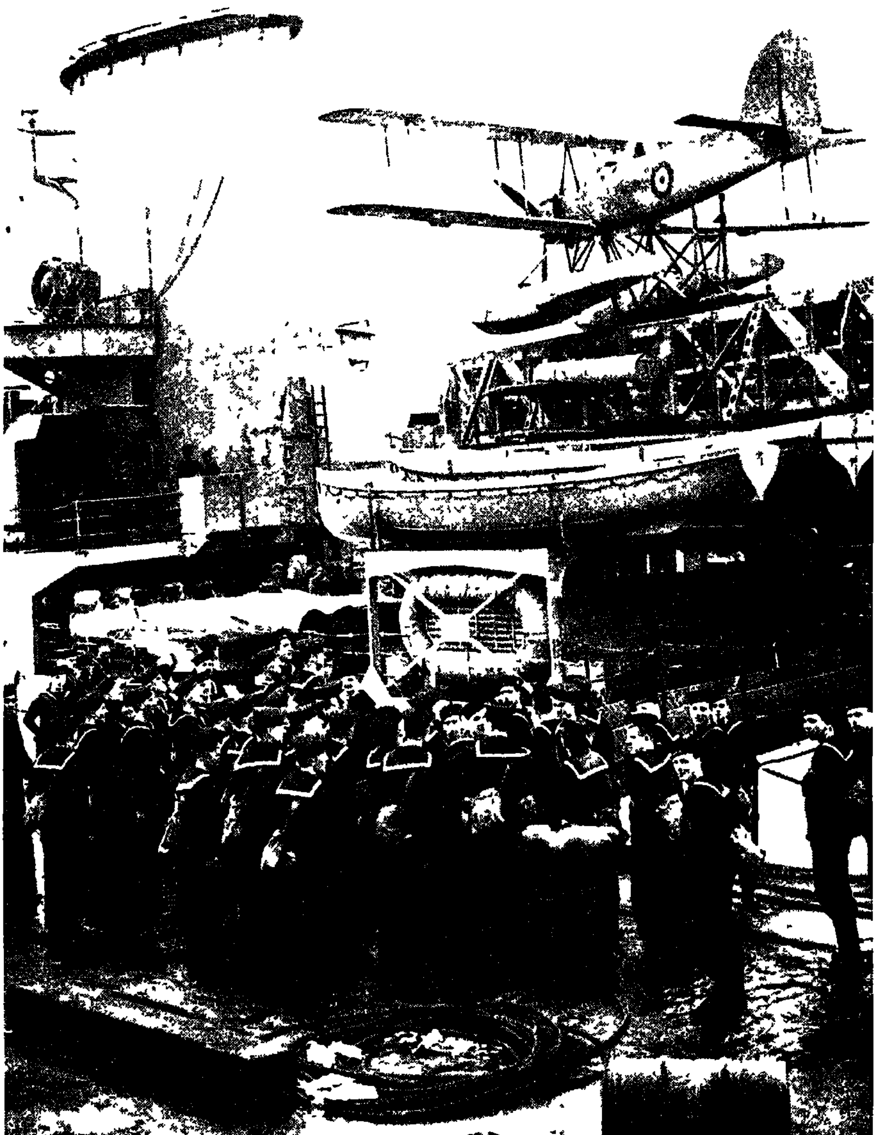
### WORK OF THE CRUISER

The cruiser is designed for all classes of work. The first is the patrol of the ocean highways, for which destroyers are not equipped. On patrol a cruiser may hunt down enemy armed raiders—as the three British cruisers, *Exeter*, *Ajax* and *Achilles*, hunted down the German raider *Admiral Graf Spee*—or she may be used to escort large convoys of merchantmen In a fleet it is the duty of the cruisers to carry out reconnaissance and to establish touch with the enemy, driving off his cruisers that are engaged on similar work.

For such duties, as well as for special work in connexion with merchant shipping, modern cruisers carry aircraft Under favourable weather conditions, these enormously extend the area the cruisers can patrol Details of the way in which these aircraft co-operate with their parent ships are given in Chapter X. In this chapter, too, will be found details of aircraft carriers, their use and operation, subjects relevant to the Fleet Air Arm

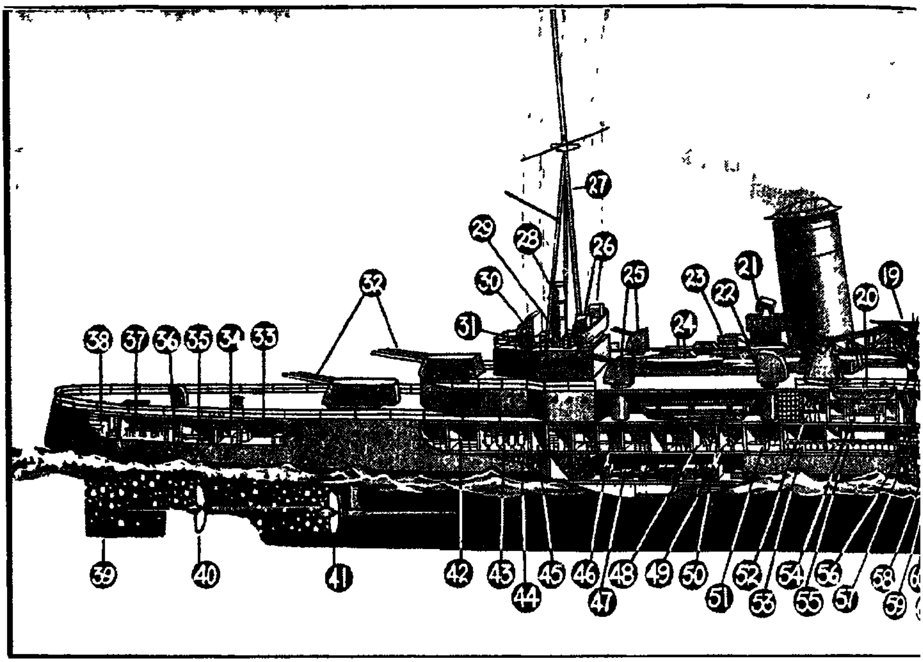
It is interesting to note here, however, that aircraft carriers play a special part in the protection of fleets against air attack

Air attack can be met not only by anti-aircraft fire, but also, of course, by fighter aircraft Aircraft carriers are usually equipped with a proportion of fighter planes These planes cannot operate directly over the fleet as they would be in peril from the anti-aircraft gunfire of the ships. Like battleships, other classes of warships are today protected



AIRCRAFT ON THE CRUISER, H M S "AJAX"

*H M S "Ajax" is typical of the cruisers used for patrol work She carries two aircraft, one of which can be seen in this picture, and a catapult In battles at close range, like the Battle of the Plate, a cruiser does not normally use her aircraft At longer ranges they may be used to "spot" for the guns and for patrol work After taking part in the celebrated Battle of the Plate, after which the German pocket battleship "Admiral Graf Spee" was scuttled, H M S "Ajax" returned home to Plymouth*

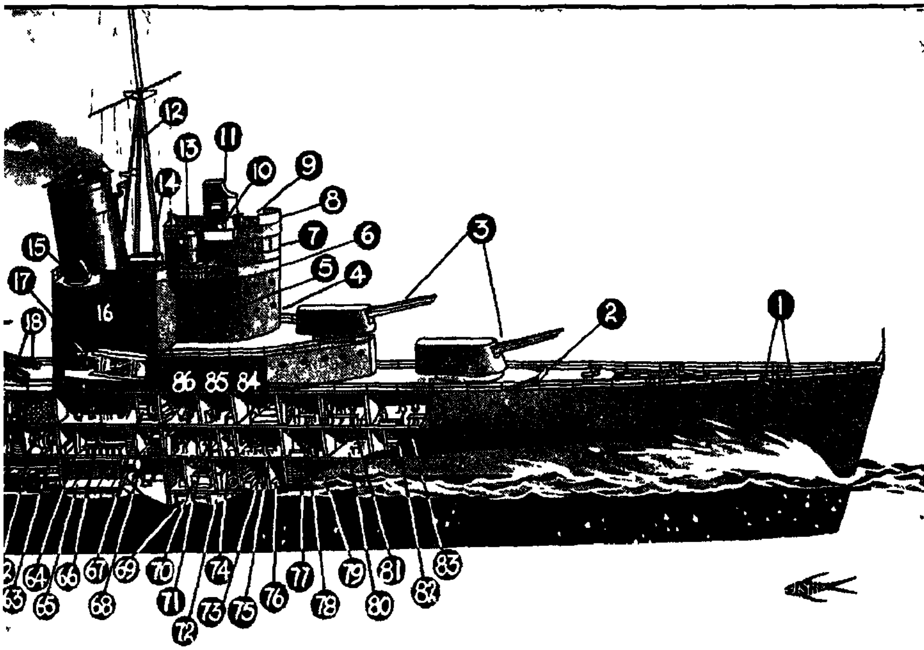



DETAILS OF THE

**Fig. 11.** *1, Anchors 2, Breakwater 3, Triple 6-inch guns 4, Wheelhouse flat 5, Paravane stowed 6, Charthouse flat 7, Upper bridge flat 8, Sliding screens 9, Upper bridge 10, Signalling searchlight 11, Director tower for 6-inch guns 12, Tripod foremast 13, Director tower 14, Boiler-room vent 15, Multiple pom-pom 16, Starboard aircraft hangar 17, Aircraft stowed in hangar 18, Cranes stowed 19, Aircraft resting on catapult 20, Twenty-seven-foot whaler 21, Thirty-six-inch signalling searchlights 22, Twin 4-inch anti-aircraft gun (port ditto) 23, Engine-room vent 24, Thirty-five-foot motor boats 25, Twin 4-inch anti-aircraft gun (port and starboard) 26, Thirty-six-inch searchlights 27, Tripod mainmast 28, Director tower 29, Machine guns 30, Director tower 31, Three-pounder saluting guns 32, Triple 6-inch guns 33, Admiral's office 34, Secretary 35, Flag lieutenant 36, Admiral's pantry 37, Admiral's dining cabin 38, Admiral's day cabin 39, Rudder 40, Starboard inner*

against aerial attack, and carry special types of guns on high-angle mountings to repel such attacks (these guns are dealt with in a later chapter). As an additional protection for groups of ships sailing in convoy, which unless widely scattered represent a large target from the air, a number of specially designed anti-aircraft ships have been introduced into the British Navy. These are converted cruisers (Fig. 12) in which the original armaments have been replaced by batteries of anti-aircraft guns, some of which can be used against surface attack as well These anti-aircraft ships are of great value to ships in harbour, where there are few shore batteries

After the cruiser we come to the destroyer, possibly the most hard-working and ubiquitous vessel in the Navy Modern destroyers have been evolved from a type first known as the "torpedo boat destroyer," whose functions are sufficiently explained by the name. In addition to destroying torpedo boats, they may be required to repel the attacks of enemy destroyers seeking to torpedo larger ships, to hunt submarines, and to



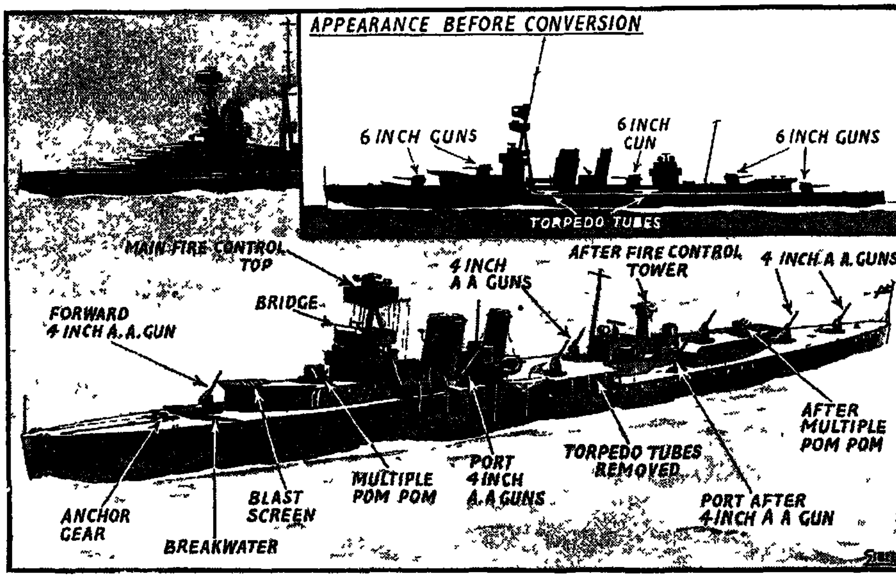

CRUISER "SOUTHAMPTON"

*propeller. 41, Starboard outer propeller 42, Officers' cabins 43, Gun room 44, Main wireless office 45, Pantry 46, Officers' cabins 47, After engine rooms 48, Pay office 49, Engineers' office 50, Torpedo tubes 51 and 53, Engine-room artificers' wash space 52, Shipwrights' workshop 54, Bakery 55, Seamen's wash space 56, Store 57, Aircraft catapult 58, Ordnance artificers' shop 59, Engine rooms 60, Diving gear 61, Electricians' shop 62, Beef store 63, Fans 64, Marines' wash space 65, Forward boiler. 66, Chief petty officers' mess. 67, Pantry 68, Fans 69, Transmitting station 70, Air filtration plant 71, Marines' mess. 72, Freshwater tanks 73, Auxiliary wireless office 74, R M sergeants' mess. 75, Boys' mess 76, Lower steering position 77, Gunners' anti-gas store 78, Seamen's mess. 79, Petty officers' mess 80, Stokers' mess 81, Seamen's mess 82, Stokers' mess 83, Seamen's mess 84, Sick bay 85, Medical examination room 86, Dental surgery.*

take on many tasks allotted to cruisers.

All modern destroyers are equipped with torpedo tubes, usually mounted in groups of four or five, and they are therefore, for their size, amongst the most deadly of all craft. Like cruisers, destroyers vary in size considerably, and in the British Navy there are many different types. A representative destroyer of one of the latest types is illustrated in Fig. 13.

The duties of a destroyer are manifold. In a fleet action they are extensively used to protect the capital ships from torpedo attacks, delivered either by surface vessels or by submarines. Their very high speeds (some modern destroyers of the British Navy are capable of speeds in excess of thirty-seven knots) enable them literally to circle round the slower moving capital ships should it be necessary. In an action in which the capital ships were compelled to turn away from the enemy, destroyers would be used to deliver torpedo attacks against the approaching enemy ships. Again, their speed and their relatively small size, which make them a difficult target, equip them admirably for this work.




FLOATING ANTI-AIRCRAFT BATTERY—A CONVERTED CRUISER

**Fig. 12.** *Some old-type cruisers have been converted into veritable floating anti-aircraft batteries Their original armaments have been replaced by anti-aircraft guns of all types, and some of the 4 7 dual-purpose guns which can be used against surface craft as well They are extremely useful to protect convoys of merchant ships, fleets at sea and harbours*

The destroyers of the British Navy, however, are used principally for patrol duties and convoy work. They are indeed the watchdogs of the sea and on their unremitting labours, the protection of the merchant shipping, on which Britain depends for her vital supplies, is based Not only do they protect the ships in convoy against raids by enemy destroyers or aircraft, but they also guard them from attack by the submarine. This aspect of their work is dealt with in Chapter IX.

### CONTRABAND CONTROL

Their duties also require them to police the seas, to round up any stray enemy merchant ships that may be endeavouring to slip back to their home ports, and to bring into the contraband control stations any neutral shipping that tries to evade the control.

Destroyers are not armoured, and their main armaments, apart from torpedo tubes, consist of from four to eight guns, the usual calibre of which is 4.7 inches Relative to their size, their engines are enormous, and every bit of unnecessary weight is sacrificed in order to attain more speed. A high degree of manœuvrability is also essential to a destroyer. Further aspects of the work and duties of this type will be revealed in later chapters

The submarine is also dealt with fully in a later chapter, and need not be described here.

The remaining ships comprised in a navy are generally classed together as miscellaneous or minor vessels. This is not to say that they are less important than the larger warships, or that their duties are less exacting, for often the contrary is true. Most of them are known by names that are explanatory of their duties. There are, for example, minesweepers, minelayers, escort vessels, net layers, boom defence vessels, motor

torpedo boats, supply ships, repair ships, and a host of other vessels.

In wartime some of these vessels may be converted merchantmen. This is particularly true of minesweepers, which in wartime are recruited very largely from the fishing trawlers of Britain's merchant fleet. The work of these vessels is dealt with in later chapters.

Three other types of ships remain to be mentioned. First comes the monitor type, designed specially for attacking fortresses or other land objectives. It is always a shallow draught vessel and is usually armed with one or two very large guns. In this sense, it is really designed as a movable sea battery. Speed is unimportant to the monitor's work, and it is seldom heavily armoured. Its shallow draught enables it to approach much closer inshore than a capital ship

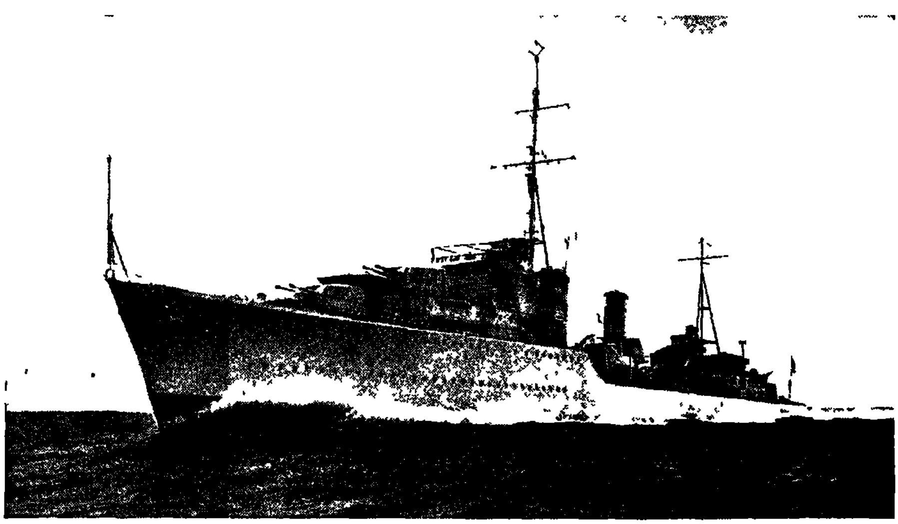
Gunboats are also shallow draught vessels, armed with light guns and machine guns. Their armaments never exceed one or two light guns. They are used chiefly for river patrol work, and Britain maintains a number on the China Station, where they patrol the Yangtze Kiang and other rivers

Finally, there is the surveying vessel. It does not rank as a fighting ship, but its work is of vital importance to the Navy. On such ships depends the proper charting of the oceans of the world and the coastal waters of the continents From the results of this work are compiled the maps and charts without which the power of the Navy would be halved. Charts, it will be appreciated, are essential to the Navy's work, and the lives of hundreds of thousands of British seamen depend on the accuracy with which the surveyors in these ships do their work.

### OFFICERS AND MEN

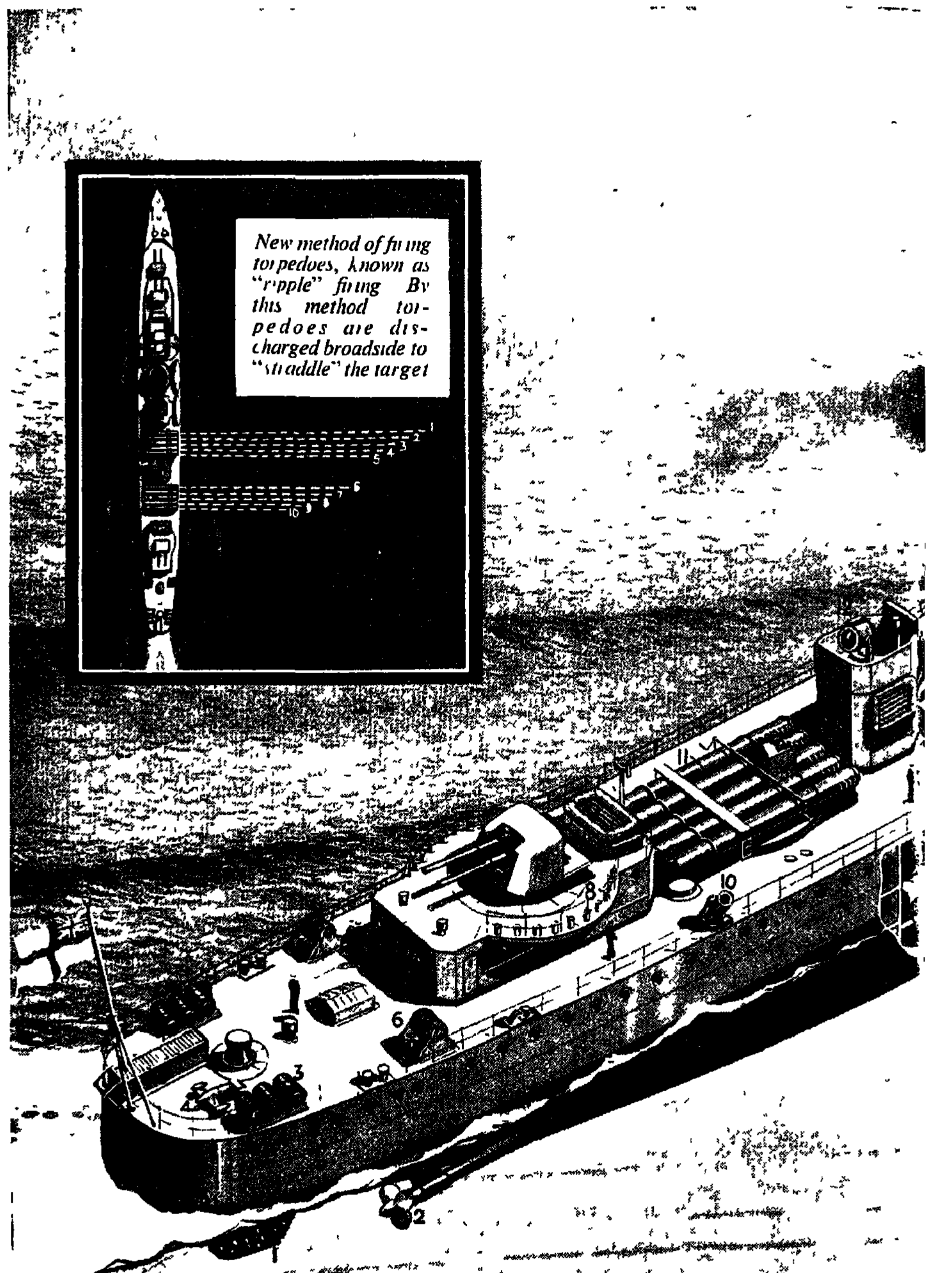
Having learnt something of how the Navy is organized and of the ships that comprise it, let us now turn to the men, the sailors who man and fight those ships.

First a note as to uniforms and ranks. There are three general classes of uniforms worn by the personnel of the Navy.



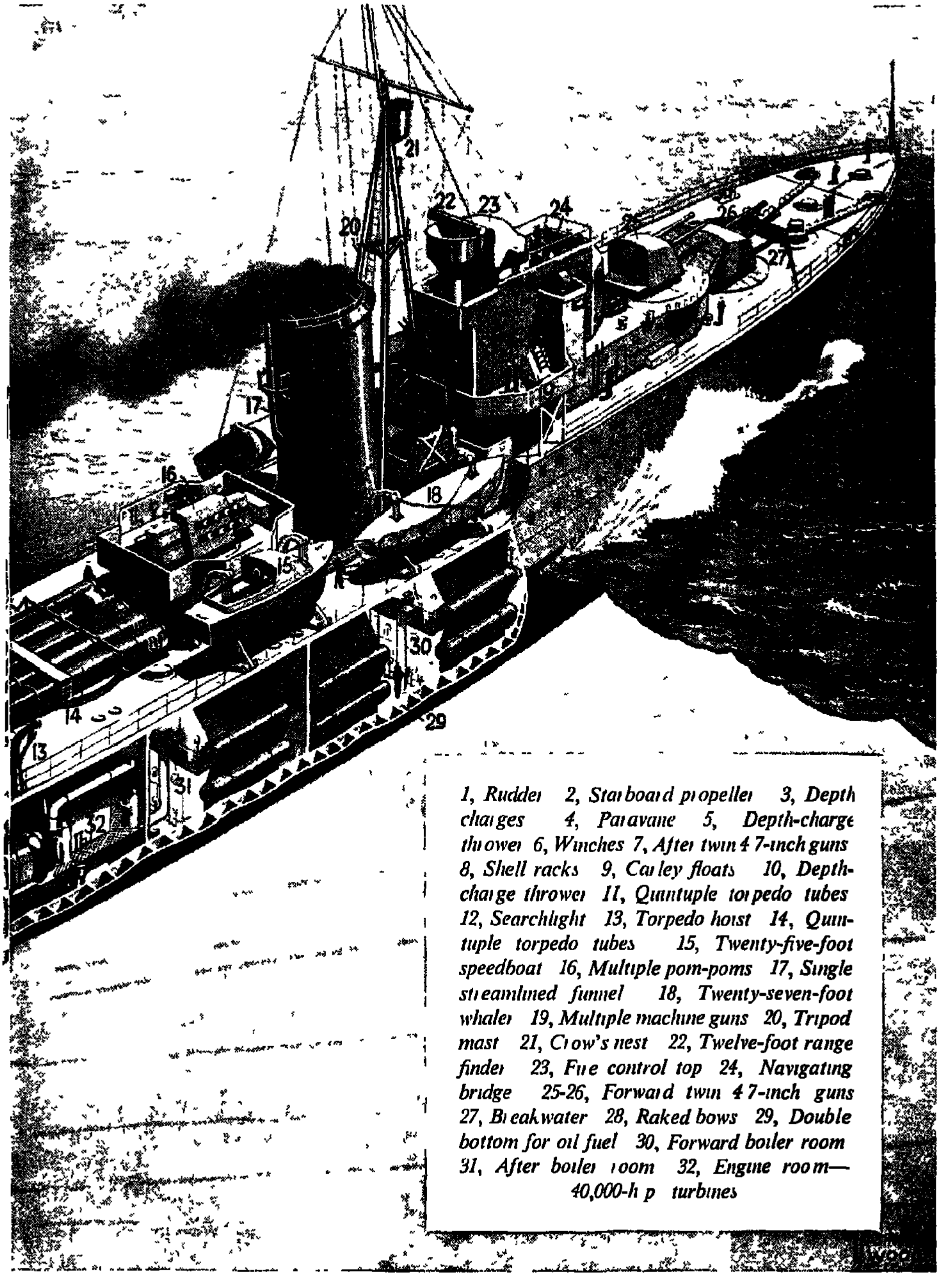
A DESTROYER AT FULL SPEED

*Destroyers, which in a naval action are used to launch torpedo attacks on enemy capital ships, are very fast and perform a multitude of other duties, particularly hunting submarines.*




SOME DETAILS OF BRITAIN'S

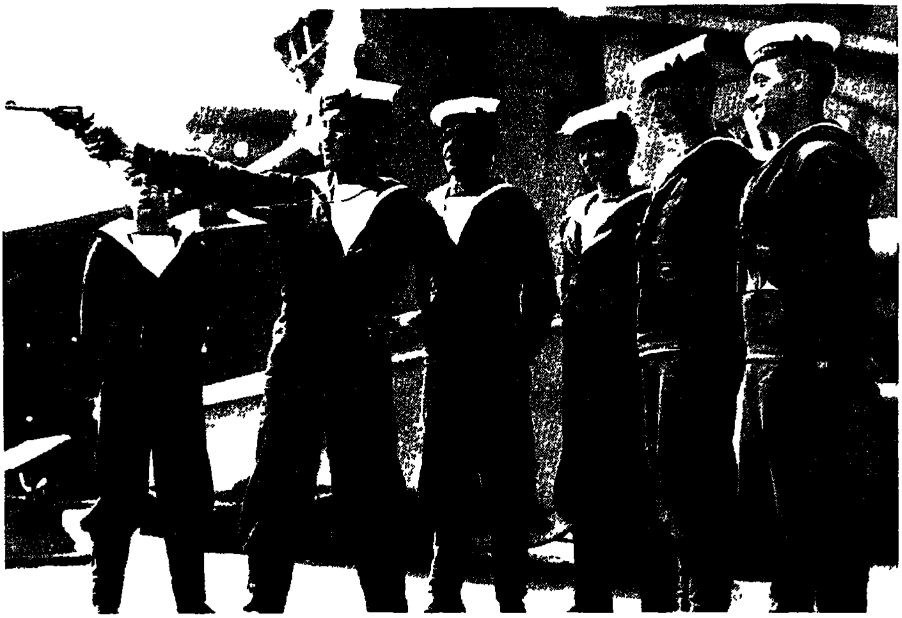
**Fig. 13.** *For the first time in many years a single-funnel design was adopted for the new "J," "K" and "L" classes They are of 1,690-tons displacement and mount six 4 7-inch*




*1, Rudder 2, Starboard propeller 3, Depth charges 4, Paravane 5, Depth-charge thrower 6, Winches 7, After twin 4.7-inch guns 8, Shell racks 9, Carley floats 10, Depth-charge thrower 11, Quintuple torpedo tubes 12, Searchlight 13, Torpedo hoist 14, Quintuple torpedo tubes 15, Twenty-five-foot speedboat 16, Multiple pom-poms 17, Single streamlined funnel 18, Twenty-seven-foot whaler 19, Multiple machine guns 20, Tripod mast 21, Crow's nest 22, Twelve-foot range finder 23, Fire control top 24, Navigating bridge 25-26, Forward twin 4.7-inch guns 27, Breakwater 28, Raked bows 29, Double bottom for oil fuel 30, Forward boiler room 31, After boiler room 32, Engine room—40,000-h p turbines*

NEW SUPER DESTROYERS

*guns in twin turrets The most interesting feature is their torpedo armament—ten 21-inch tubes in sets of five A new method of firing torpedoes is shown in the inset on the left at top.*



PISTOL INSTRUCTIONS ON H M S "IRON DUKE"

*These signal boys are being trained in the use of the pistols which they carry when a landing party goes ashore H M S "Iron Duke" is a naval training ship*

There is the sailor's rig, which includes the familiar bell-bottomed trousers and the peakless cap, the petty officer's dress with its reefer jacket and smart peaked cap, and the commissioned officers' uniform distinguishable by the bands of gold braid on the sleeves. The various badges and rank markings of the Navy are shown in Figs. 14, 15 and 15A.

### TWO CLASSES OF RATINGS

Apart from the men, such as cooks, barbers and tailors, who look after what may be termed the "domestic" side of the work in a warship, the ratings may be divided into two main classes. One class is concerned with the executive work of the ship—manning the guns, steering, signalling, and so forth. These men are seamen ratings or ratings with special qualifications according to the work they do. The other class comprises the stokers—a term that may suggest a picture of stripped men shovelling coal into the furnaces. Such a picture, however, has nothing to do with the stokers of the Navy of today. Warships now are fuelled by oil and as a result the work of a stoker has become more of an engineer's job Besides maintaining the supply of oil to the boilers, he is concerned with the care and maintenance of the boilers and their accessories.

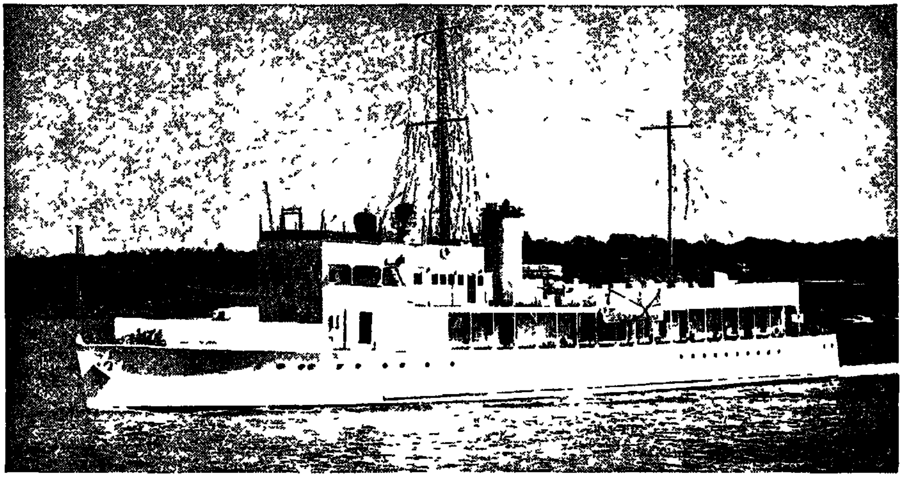
Ratings may join the Navy either as boys or when older. The boys receive their training under peace-time conditions, at one of four establishments, at Rosyth, Shotley (near Harwich), Portsmouth and Devonport. These four establishments are known respectively as H M.S. *Caledonia*, *Ganges*, *St. Vincent* and H M S. *Impregnable*. Although ratings may rise to the rank of petty officer as they gain in qualifications, by far the largest number of petty officers hold their rank because they are artificers

—the highly-qualified mechanics of the Navy. There are many different branches of engineering in which they may be qualified, and they may be either engine-room artificers, electrical artificers, or ordnance artificers, the last being concerned with the armament of a ship

Artificers may join when boys as artificer apprentices, or they may join later in life when they have become qualified in some branch of engineering.

Like the ratings of the Navy, the executive officers, and as such are called upon to exercise normal commands.

The rank of the officer commanding a ship varies with the size and type of ship. For instance, a lieutenant may be in command of a submarine or other smaller craft Promotion for all officers in the Navy is automatic up to the rank of lieutenant-commander, but above this rank, promotion is based entirely on merit. As some confusion prevails as to the equivalent Army and Air Force ranks

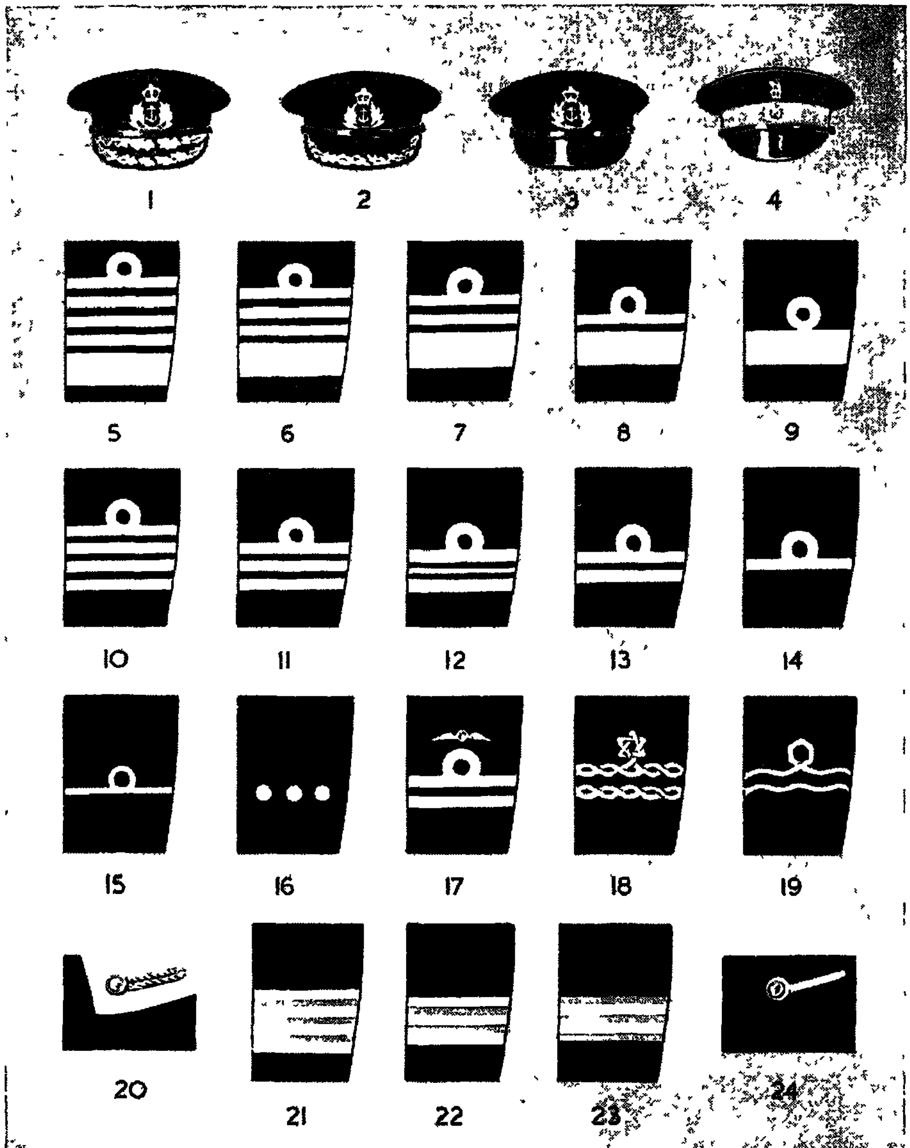


A BRITISH GUNBOAT FOR CHINESE RIVER PATROL

*These shallow draught, lightly-armed vessels are specially designed to protect British shipping on rivers and estuaries They seldom go to sea.*

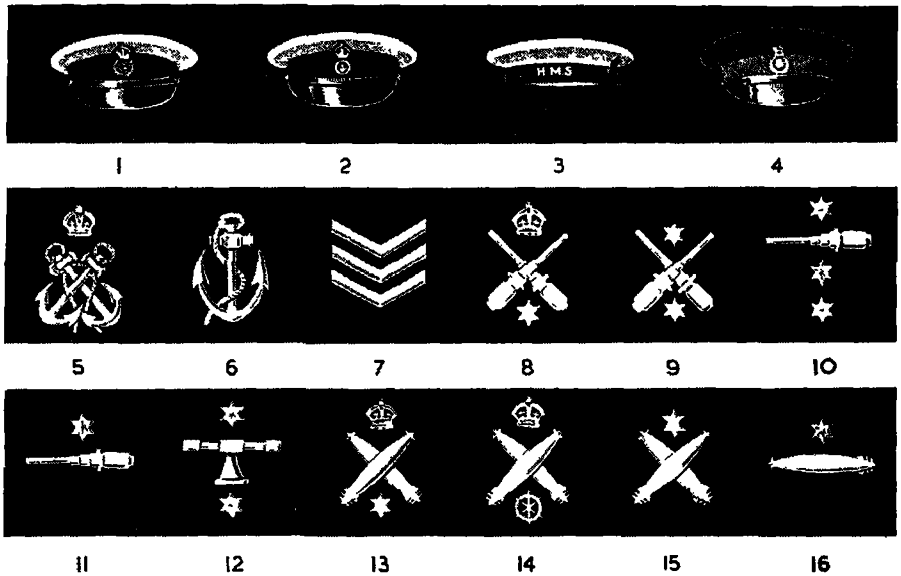
officers are divided into groups, of which the most important are the Military (or Executive) Branch and the Engineering Branch. There are also the Instructor, Accountant and Medical Branches. Normally, the officers of the Engineering Branch receive training in seamanship as cadets, but once entered for duty in the Engineering Branch they remain in it The officers of the Executive Branch may also specialize in different subjects, such as navigation, gunnery, torpedo, submarine, and signals, but they do not remain permanently in specialized categories They are first and foremost an explanatory table is given in Fig. 16

As with the men in other Services, sailors have periods of off duty at regular intervals, but unlike life in the other Services, there is little difference between the routine of a sailor in peace time and in wartime. Tremendous dangers have to be faced, of course, in wartime, and there are hard periods of duty and fighting when ships are in contact with the enemy. But apart from this actual fighting, and the ever-present danger, the work to be done in peace time is very similar to that of wartime. Whether in peace or war, the engines have to be kept going and cared




CAPS AND SLEEVE MARKINGS OF NAVAL OFFICERS

**Fig. 14.** *1, Flag officers 2, Captains and Commanders 3, All other officers 4, Royal Marine officer's cap, Majors and over wear oak leaves similar to No 2 5, Admiral of the Fleet 6, Admiral 7, Vice-Admiral 8, Rear-Admiral and Commodore first class 9, Commodore second class 10, Captain 11, Commander 12, Lieutenant-Commander 13, Lieutenant 14, Sub-Lieutenant and Commissioned Warrant Officer 15, Warrant Officer. 16, Midshipman. 17, Lieutenant in Fleet Air Arm 18, Lieutenant R N R 19, Lieutenant R N.V R. 20, Midshipman's "patch" on lapel of collar 21, Engineer officers 22, Medical officers 23, Paymaster officers 24, Naval cadet's "patch" on lapel of collar*




RANKS AND MARKINGS OF NAVAL RATINGS

**Fig. 15.** *1, Chief Petty Officer 2, Petty Officer. 3, Seaman all classes 4, Royal Marines, N C O s and lower ranks 5, Petty Officer 6, Leading Seaman 7, Good conduct badges. one stripe, three years and over, two stripes, eight years and over, three stripes, twelve years and over 8, Gunner's Mate 9, Director Layer 10, Captain of Gun, first class 11 Chief Petty Officer, Petty Officer and Leading Seaman, Sergeant Gunner and Seaman Gunner. 12, Range-taker, first class 13, Torpedo Gunner's Mate 14, Torpedo Coxswain 15, Leading Torpedo man 16, Chief Petty Officer, P O , Leading Seaman, Sergeant and Seaman Torpedo man*

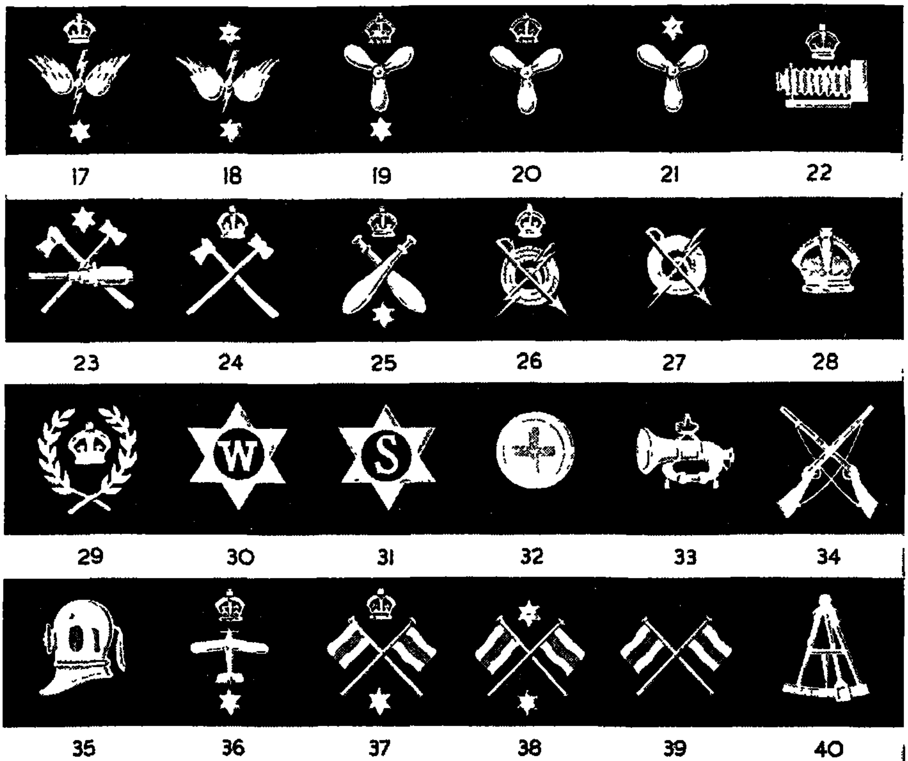
for, ships must be navigated, and constant watch by look-outs must be maintained. The ships also have to be kept clean and in trim.

The everyday life of a sailor begins at an early hour and is regulated throughout by a fairly strict routine. The routine varies with the type of work for which the rating is qualified, and also with the duties he may be performing It also varies with the work on which the ship is engaged. In wartime, of course, the routine may be modified to fit the service for which the ship may be detailed.

When the ship is at sea on patrol, except during his watches, or in emergency, the sailor has his time free. The work he does obviously depends on his specialized qualifications. He may be an artificer or he may be a cook, and according to whether he is one or the other, so he will carry out his duties in the engine room or the cook's galley.

Time on board is regulated by "bells," and this system of "bells" is a mystery to the great majority of "landlubbers."

The day for the Navy is divided up into a number of watches. Of these there are seven, consisting of five watches each of four hours and two watches each of two hours. These shorter watches are known as "Dog Watches"—First Dog Watch and Last Dog Watch. Each watch is timed separately and the bell is struck every half-hour. During an ordinary watch, therefore, the time is indicated by striking the bell eight times, starting with "one bell" and finishing with




RANKS AND MARKINGS OF NAVAL RATINGS

**Fig. 15a.** *17, Wireless Telegraphist, first class 18, Wireless Telegraphist, third class 19, Mechanician 20, Chief Petty Officer and Petty Officer Stoker 21, Leading Stoker and Stoker, first class 22, Chief Photographer 23, Chief Armourer and Armourer 24, Chief Shipwright 25, Physical and Recreational Training Instructor, first class 26, Submarine Detector Instructor 27, Submarine Detector Operator 28, Regulating Petty Officer. 29, Master-at-Arms 30, Writer 31, Supply Rating 32, Sick Berth Attendant 33, Bugler 34, Marksman badge (musketry) 35, Diver. 36, Observer's Mate 37, Visual Signalman, first class 38, Visual Signalman, third class 39, Ordinary Signalman 40, Surveying Recorder*

"eight bells." Naturally, during a Dog Watch the bell is struck only four times. For the First Dog Watch—a two-hour period—there are one, two, three and four bells. For the Last Dog Watch, however, there are one, two, three and eight bells. The eight bells, of course, signifies the end of the Dog Watches.

A day commencing at noon would be divided in this way:—

| WATCH | BELLS |
|---|---|
| Afternoon | Noon to 4 p.m., 1 to 8. |
| First Dog | 4 p.m.—6 p.m , 1, 2, 3, 4. |
| Last Dog | 6 p.m.—8 p.m., 1, 2, 3, 8. |
| First | 8 p.m.—midnight, 1 to 8 |
| Middle | Midnight—4 a.m., 1 to 8 |
| Morning | 4 a.m.—8 a.m., 1 to 8. |
| Forenoon | 8 a.m.—noon, 1 to 8. |

The effect of having seven watches in the day is that a rota is automatically established amongst the crew, and every member changes the time of his watch from day to day. Normally, the watch parties are divided into two, each half

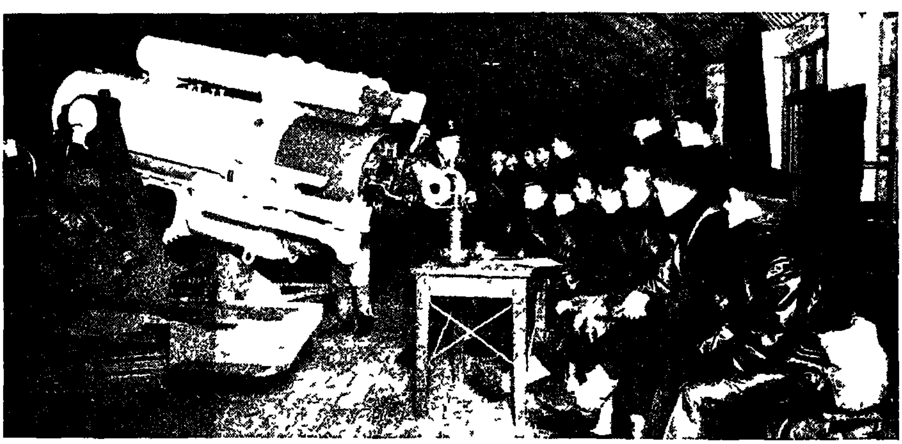
| ROYAL NAVY | ARMY | ROYAL AIR FORCE |
|---|---|---|
| **Commissioned Warrant Officer** | **Second Lieutenant** | **Pilot Officer** |
| **Sub-Lieutenant** | **Lieutenant** | **Flying Officer** |
| **Lieutenant** | **Captain** | **Flight Lieutenant** |
| **Lieutenant-Commander** | **Major** | **Squadron Leader** |
| **Commander** | **Lieutenant-Colonel** | **Wing Commander** |
| **Captain** | **Colonel** | **Group Captain** |
| **Commodore** | **Brigadier** | **Air Commodore** |
| **Rear-Admiral** | **Major-General** | **Air Vice-Marshal** |
| **Vice-Admiral** | **Lieutenant-General** | **Air Marshal** |
| **Admiral** | **General** | **Air Chief Marshal** |
| **Admiral of the Fleet** | **Field Marshal** | **Marshal of the Royal Air Force** |

**Fig. 16.** *The equivalent officer ranks of the Navy, Army and Air Force. As between officers of equivalent rank in different Services, naval officers always take seniority.*

keeping watch while the other rests.

It is impossible, so multifarious are the duties that sailors perform, to describe in any detail the daily life of a sailor. But some idea of an ordinary day on board a British ship in harbour in any European port may be given.

The day begins at 5.30 a.m. when *reveille* is sounded by the bugler. Loud-speakers throughout the ship issue the order "Call the hands." The sailor at once turns out of his hammock and proceeds to pack it up with the regulation seven turns. It is then stowed away for the day. Watch keeping, both above deck and below in the engine rooms, goes on continuously, and those on watch are not concerned with the ordinary routine. At 5.40 a.m. hot cocoa is provided, and the sailor has time for a quick smoke and a wash before "hands fall in" is called at 6 a.m. This is

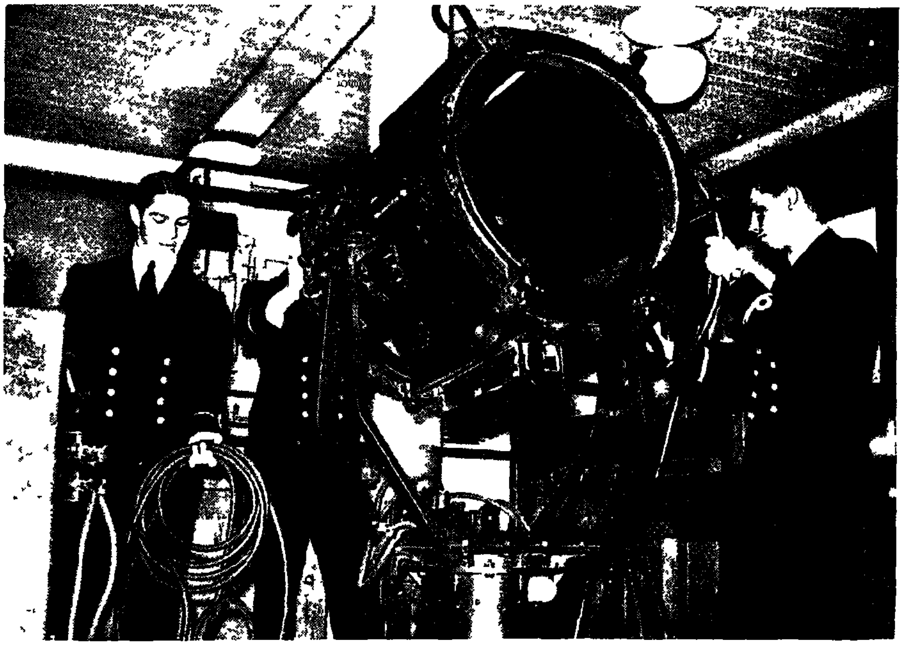


WHERE NAVAL GUNNERS ARE TRAINED

***A class at the naval gunnery school on Whale Island, at Portsmouth. The high standard of gunnery shown in the Battle of the Plate resulted from this training***

CAMEOS OF THE SAILOR'S ROUTINE

(A) *Marines form a guard of honour for H M the King coming aboard H M S. "Effingham"* (B) *Ratings on the navigating platform* (C) *"Splicing the mainbrace" Ratings receive their rum and tobacco ration* (D) *The well-known bos'n's pipe* (E) *After prayers every morning, the sailor has a period of drill or physical training on the deck* (F) *Each ship has its own bakehouse and a staff of skilled bakers is included in its complement.*



COMMANDERS AND CAPTAINS OF THE FUTURE

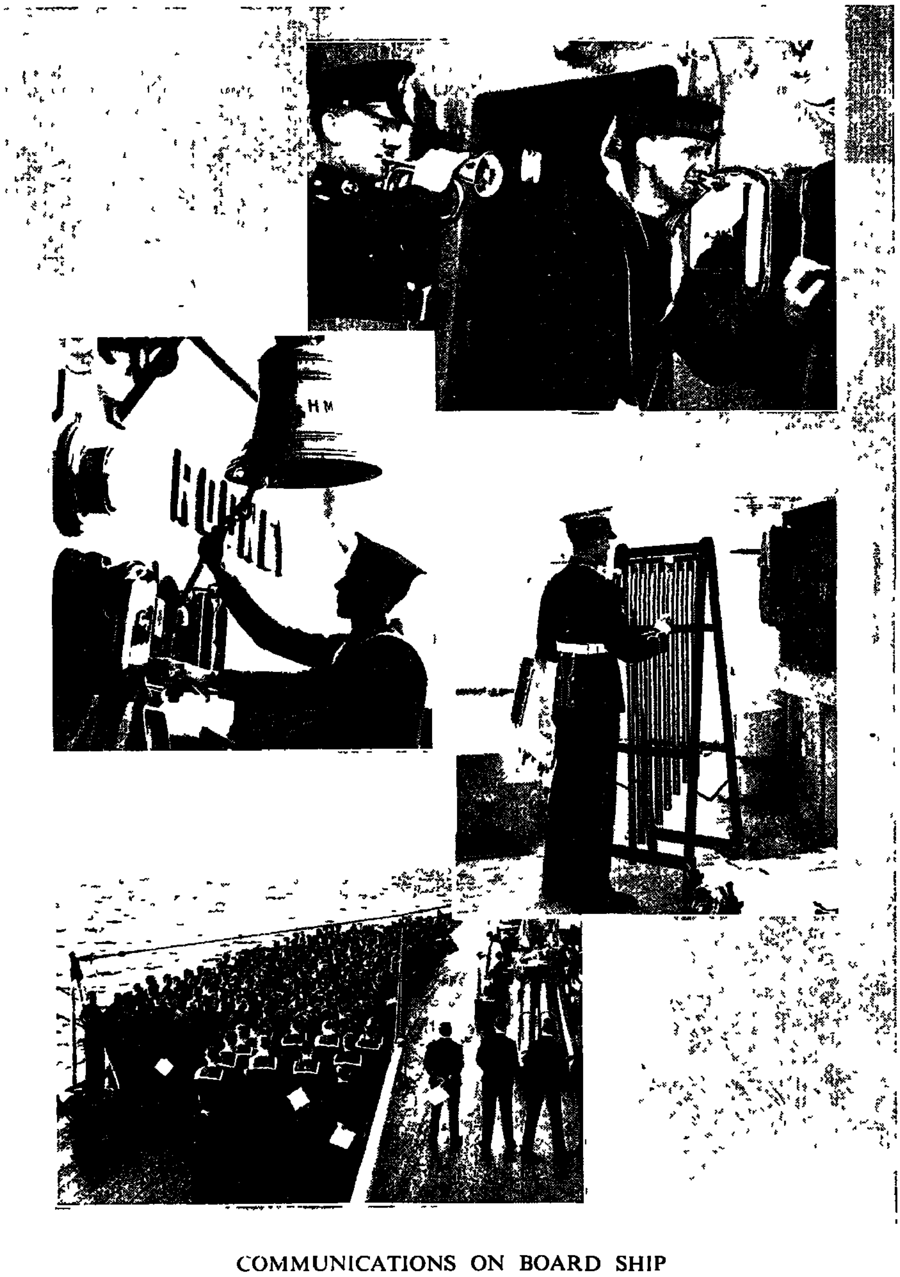
*Sub-lieutenants at the Royal Engineering College, Keyham, Devonport, learning how to operate a searchlight Executive officers may specialize in many branches.*

the principal fall-in of the day for work.

The next hour is spent in cleaning the ship. Every part, including the boats and ladders, as well as the decks, has to be cleaned. Then at 7 a.m comes the welcome call for dressing and breakfast. Having shaved and breakfasted, the sailor is ready by 8 a.m. for the maintenance cleaning work of the guns or other armament, and the removing from them of the night covers. At this hour also, the band and guard parade and the White Ensign is raised to the strains of the National Anthem.

At 9.5 a.m. the whole of the ship's company, excepting those on special duties who cannot leave their posts, parades in what is termed "Divisions," for the roll call. Roll call completed, our sailor marches aft for prayers. These are followed by a period of drill or physical training and a long period of work of more specialized nature. Repair and maintenance work is carried out according to the qualifications of the rating. A welcome break occurs at 10.30 when he is able to go to the upper deck for ten minutes to smoke. Then back to work until 11.50 a.m. when the bugle warns him to clear up ready for dinner.

After this he is free until 1.15 p.m. when follow a further two and a half hours' work according to his particular duties. Organized work ends at 3.45 p.m. and at 4 p.m. comes the afternoon muster and roll call. Often the sailor will have leave, but in any event the time is his own. Supper is normally at 7 p.m. At 7.45 p.m. the sailor may turn in if he wishes First Post is sounded at 8.45 p.m. and Last Post at 9 p.m At this hour the commander, the second in command or executive officer makes his rounds to inspect all quarters of the ship.

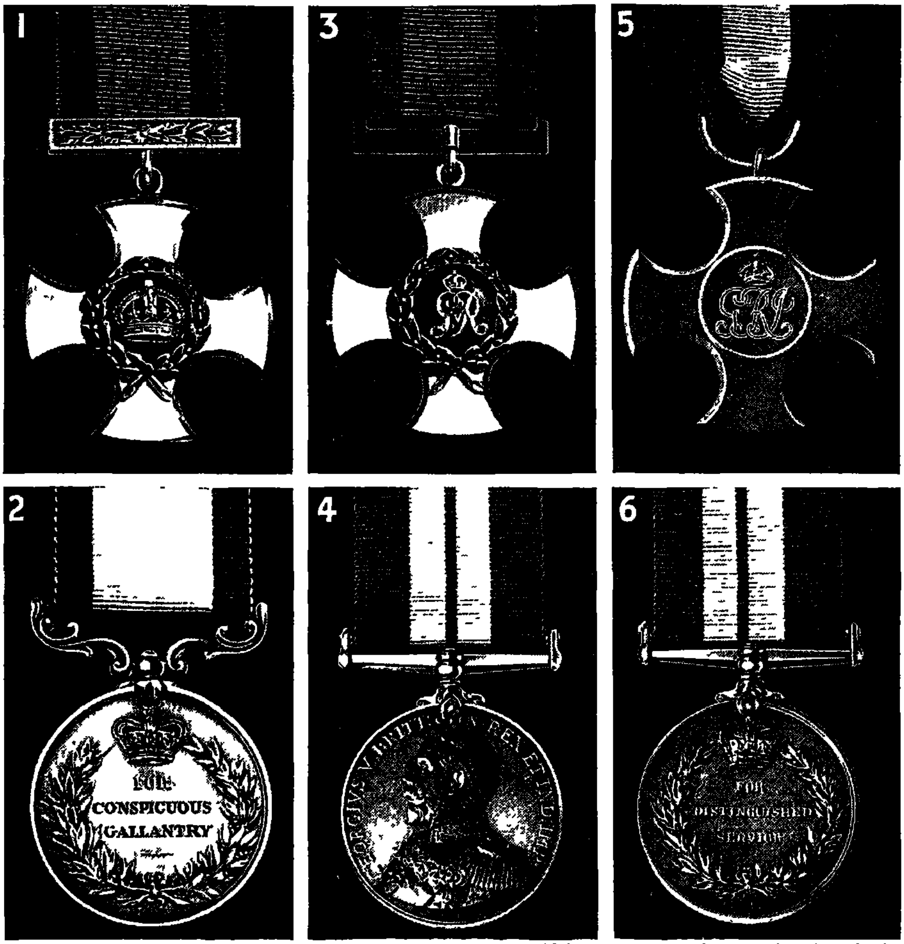



COMMUNICATIONS ON BOARD SHIP

(A) *Bugle calls and orders are relayed to all parts of a large ship by means of a microphone and loudspeaker apparatus* (B) *Striking the bell aboard H M S "Rodney" The bell is struck every half-hour (see text)* (C) *The call to prayers is sounded on the modern carillon.* (D) *A typical scene when prayers are conducted aft*


SCENES FROM A SAILOR'S DAY

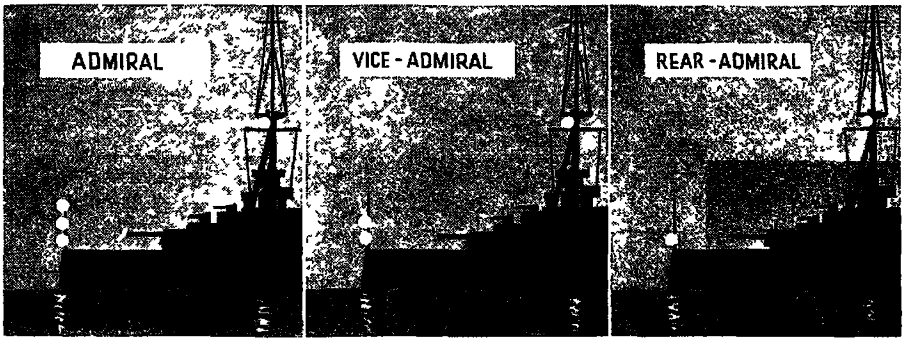
(A) *"All out" at the sound of reveille at 5 30 a m* (B) *Signaller communicating with other ships by means of semaphore flags* (C) *Warships are now fuelled by oil and the stoker has become an engineer* (D) *Swabbing down the decks, one of the sailor's most frequent jobs Daily routine of a sailor on a modern warship is described on pages 203-205.*




[Medals by courtesy of Messrs. Spink & Sons, London

DECORATIONS OF THE ROYAL NAVY

*1, Distinguished Service Order (obverse) 2, Conspicuous Gallantry Medal (reverse) 3, Distinguished Service Order (reverse) 4, Distinguished Service Medal (obverse) 5, Distinguished Service Cross (reverse) 6, Distinguished Service Medal (reverse) Although the Distinguished Service Order is illustrated only in this group of Royal Navy illustrations (as befits the "Senior Service") the decoration is awarded to an officer in any of the three Services who has been specially mentioned in dispatches for meritorious or distinguished service in the field, or before the enemy. The D S O is next in importance to the Victoria Cross (illustrated in Chapter XI) The colour of the ribbon is red in the centre and blue on the outsides The Conspicuous Gallantry Medal is awarded for acts of conspicuous gallantry in action with the enemy It is awarded to N C O s and men of the Royal Marines as well as to petty officers and men of the Royal Navy The colour of the ribbon is white with blue borders The Distinguished Service Medal is open to the same ranks as the Conspicuous Gallantry Medal, but for "acts of bravery under fire" This decoration has a ribbon of blue and white stripes The Distinguished Service Cross is awarded to all officers of, or below, the rank of commander, who have been mentioned in dispatches for meritorious or distinguished conduct. The ribbon is a white stripe bordered by two blue ones*




*Riding lights at the stern of a flagship, denoting the rank of the flag officer aboard*

At 10 p.m comes the last order of the day—"Pipe Down." With this the sailor has to turn in whether he wants to or not. Except for emergency calls—and unless he is on special duties—our sailor will now remain snug in his hammock until "Call the hands" blares over the loudspeakers and another day begins.

Further details of duties on board different types of ships and of what happens when a ship goes into action will be found in later chapters. Here we have space only to add a word about that sea-soldier, the marine.

The work of the Royal Marines today is more closely identified with that of the sailors than it was in the early days of the Navy. At one time the marines formed the fighting man-power of a warship, the sailors being merely concerned with the navigation and operation of the ship. At one time landing parties were almost exclusively composed of marines. Nowadays, although landing parties from the larger ships are still mainly composed of marines, they also include sailors.

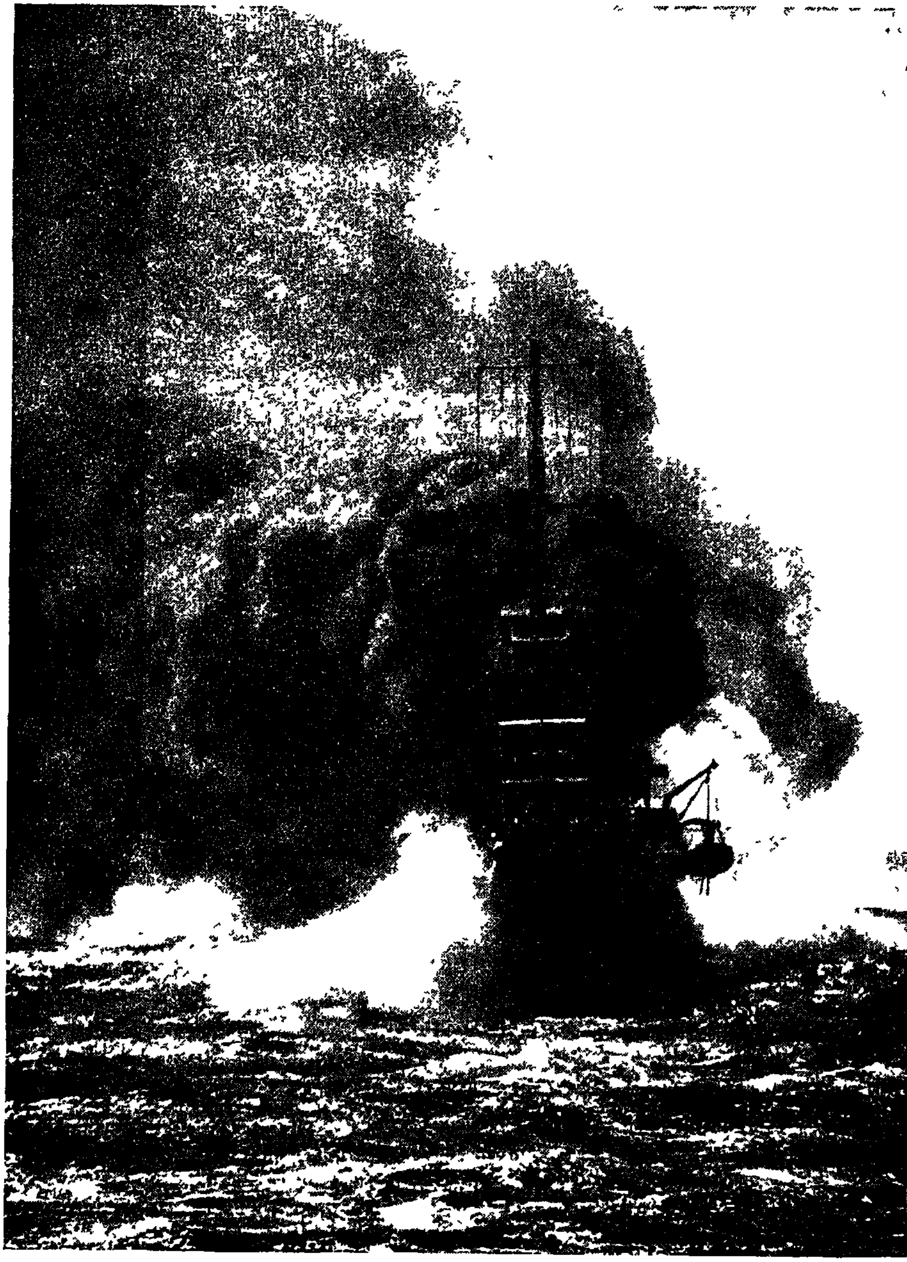
Until 1923 there were two corps of marines unofficially known as "Red Marines" and "Blue Marines" because of the colours of their uniform. One corps was nominally more concerned with infantry work and the other with artillery, though in practice both manned guns at sea The uniform of the marine of today combines the blue and the red of both corps

Marines are carried only by battleships, battle cruisers and cruisers. Ships smaller than a cruiser do not normally carry them. They comprise about one-fifth of the executive complement of their ship and, as a rule, they are responsible for providing about one-fifth of the guns' crews of the ship.

### MARINE BANDS

Among the special duties assigned to the marines is the provision of the ship's band, and the bands of the Royal Marines are famous throughout the world. There are a great number of bands—in fact about one marine in every ten is a bandsman. But because he is a bandsman he does not escape other duties, and every marine on board a ship is trained for special work Marines, for example, frequently operate the vital fire-control apparatus of a ship.

In addition to these duties, marines are used largely as sentries and as officers' servants on board ship, and they also provide guards of honour for ceremonial occasions. Royal Marine Police (pensioners) guard dockyards and other shore establishments of the Navy.



HIDE AND SEEK AT SEA

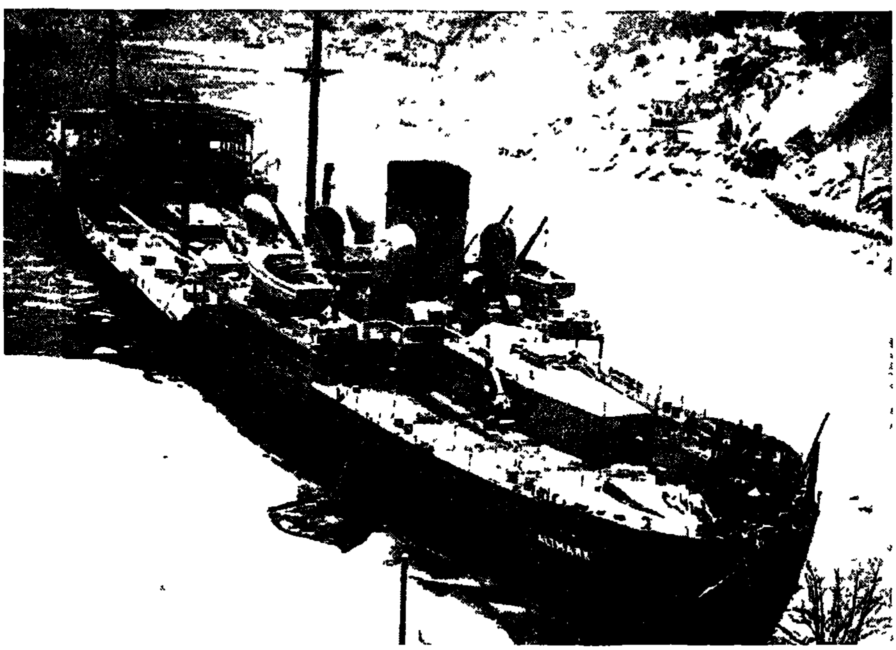
*Destroyer laying smoke screen to hide the movements of its main fleet. In an action individual ships often lay smoke screens, darting out of the cover they afford to fire at the enemy, and in again to baffle the opposing gunners, as was done at the Battle of the Plate*

CHAPTER VII

# THE NAVY AT WORK

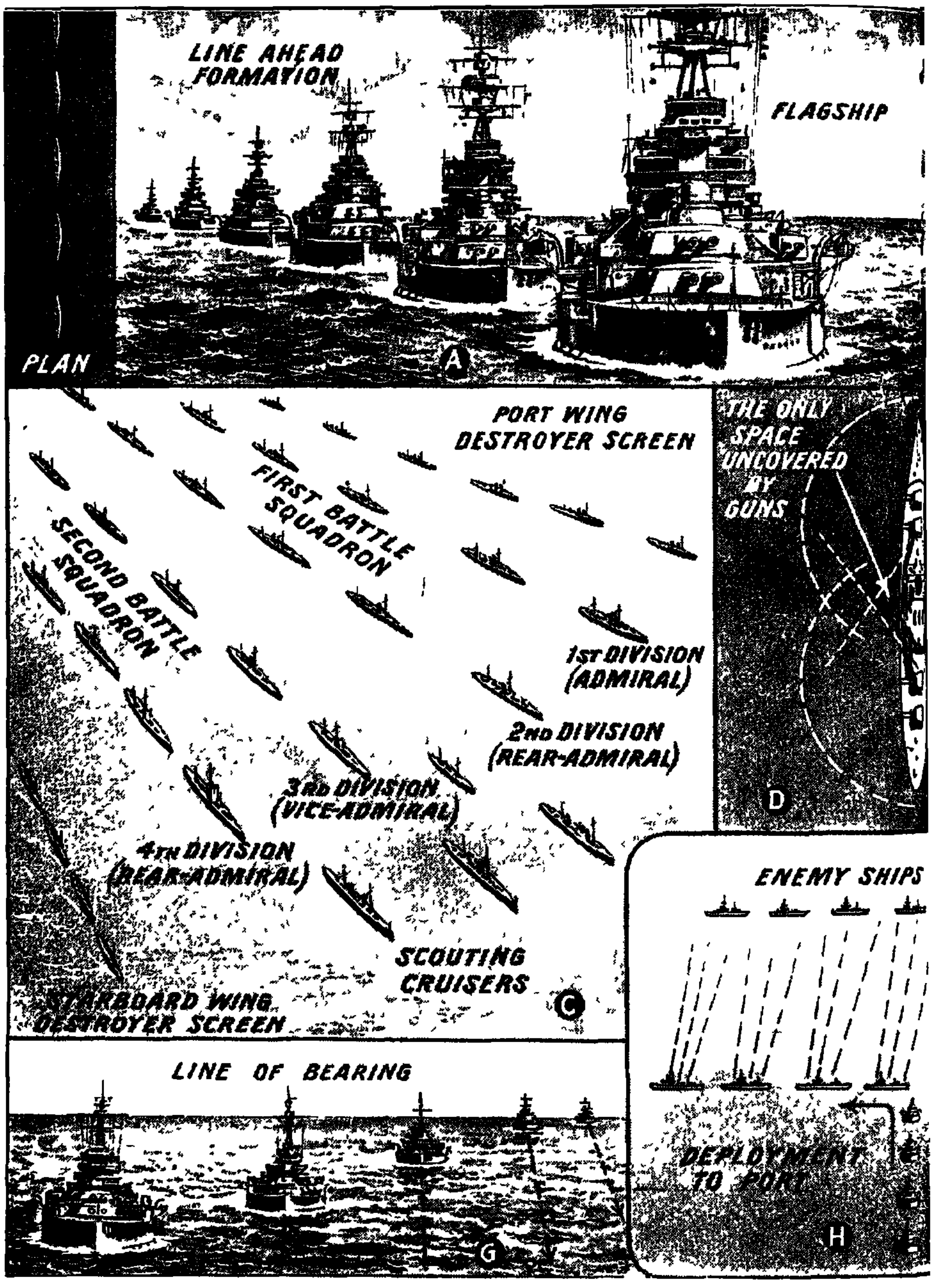
In peace and in war the Royal Navy has always regarded its work as "routine." Every job it has undertaken, no matter how spectacular, has been reported merely as another incident in its day-to-day activities. Because of this reticence the Navy has acquired the nickname "the Silent Service." In wartime warships go about their duties even more quietly than in peace time "I expect you have heard about the *Altmark* affair," a young sailor wrote on a postcard to his family, "I was there." This was the only reference he made to an action that had captured the imagination of the British public. With as little fuss as this the dull grey ships of His Majesty's Navy slip out of harbour to fulfil difficult and dangerous tasks. It is the purpose of this chapter to describe some of the more important ways in which the Navy helps Britain to win her wars and to maintain her traditional supremacy at sea.

A full-scale sea battle is the biggest action in which the Navy can be engaged. Such an action occurs when the opposing fleets meet upon the high seas. Naval battles are the rarest of all actions, because they are likely to take place only when the two opposing fleets are roughly of the same fighting strength. Nevertheless, small actions that do not involve battleships on either side are always liable to occur in wartime, and the fundamental tactics employed in bigger battles



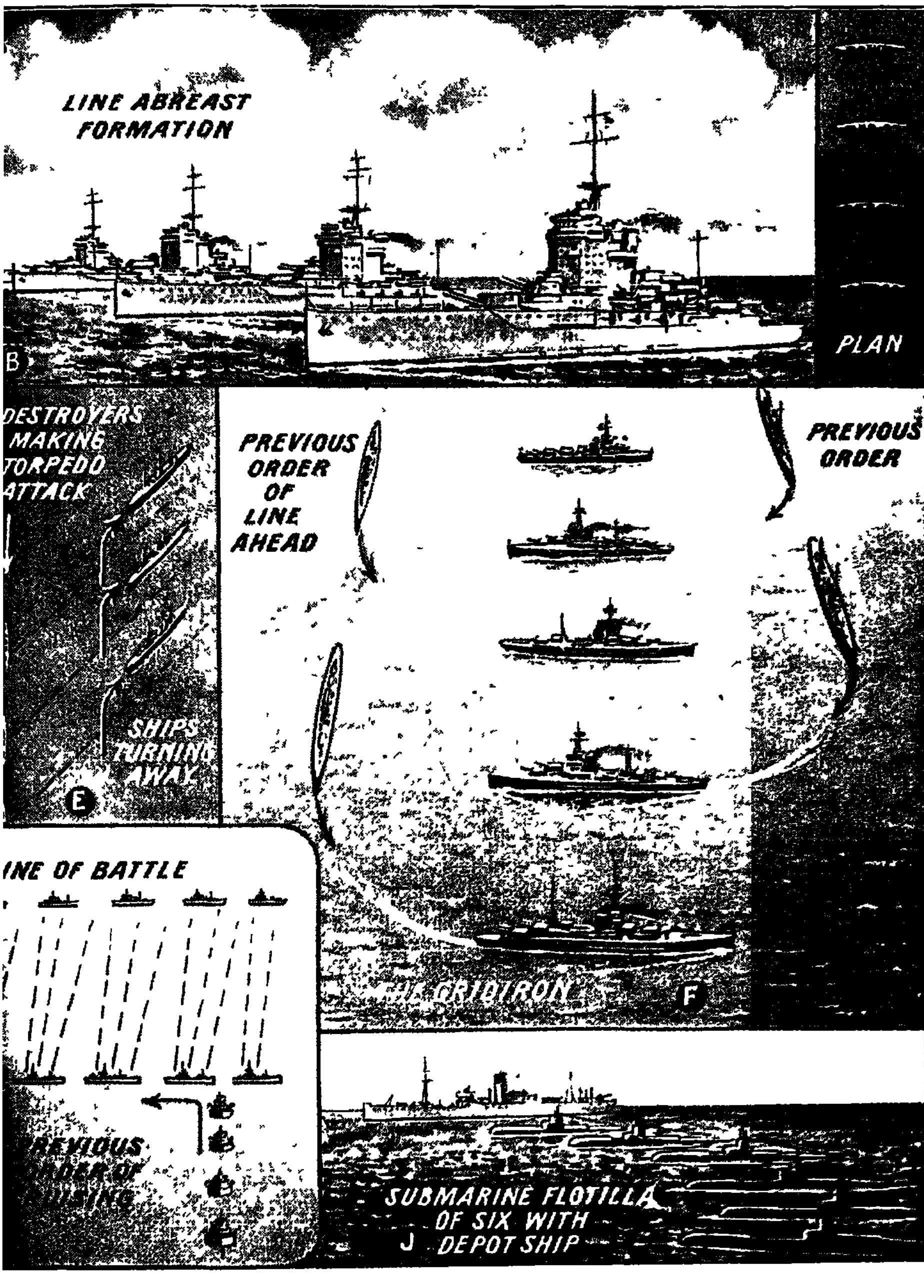
THE "ALTMARK" IN NORWEGIAN WATERS

*The Nazi prison ship "Altmark" seen aground in Josing Fjord British sailors of the mercantile marine were rescued from this prison ship by the British destroyer "Cossack"*




NAVAL FORMATIONS AND BASIC

*Line ahead formation* (A), *and line abreast formation* (B), *form the basis of all naval manœuvres* (C) *Shows a fleet in cruising formation with scouting cruisers ahead* (D) *Indicates the swivelling power of a warship's guns, while* (E) *pictures defence tactics against a torpedo*




MANŒUVRES OF A FLEET AT SEA
*attack The spectacular "gridiron" manœuvre is illustrated in* (F) *Ships steaming in parallel lines turn inwards to pass each other* (G) *Another version of line ahead* (H) *On contacting the enemy, warships deploy to port before firing* (J) *Fleet submarines with their depot ship.*

are equally applicable, in modified form, to smaller ones. It will, therefore, be worth considering these tactics in detail.

In order to understand how a naval battle is fought, three points must be considered. First of all it must be made clear how the commander-in-chief directs the action. Then one must see the various ways in which he can dispose and manœuvre his ships. Lastly, it must be explained how he can transmit his orders from his flagship to the many vessels that make up his fleet, without disclosing his manœuvres to the enemy.

### NAVAL "CHESS"

A naval action is rather like a game of chess in which the ships are the pieces and the opposing admirals are the players Each admiral is trying to force a win or to prevent his opponent forcing a win, each has a plan of campaign in mind. An admiral must study closely each move his opponent makes, not only to see whether it threatens his own ships, but also in order to decide what his own next move shall be. Throughout the battle the admiral is trying to discount the moves of his opponent and, at the same time, seeking to get into a favourable position himself. Unlike the chess player, however, an admiral dare not deliberate too long over his moves, decisions, and the right decisions, must be made quickly

The area of a naval action may extend beyond the range of vision, and if the admiral is to direct the battle properly he must know the exact positions and courses of all his own ships at any moment and the positions of as many of the enemy ships as possible. In practice, not all this information is available, but the admiral must have as clear a picture of the battle as it is possible to obtain

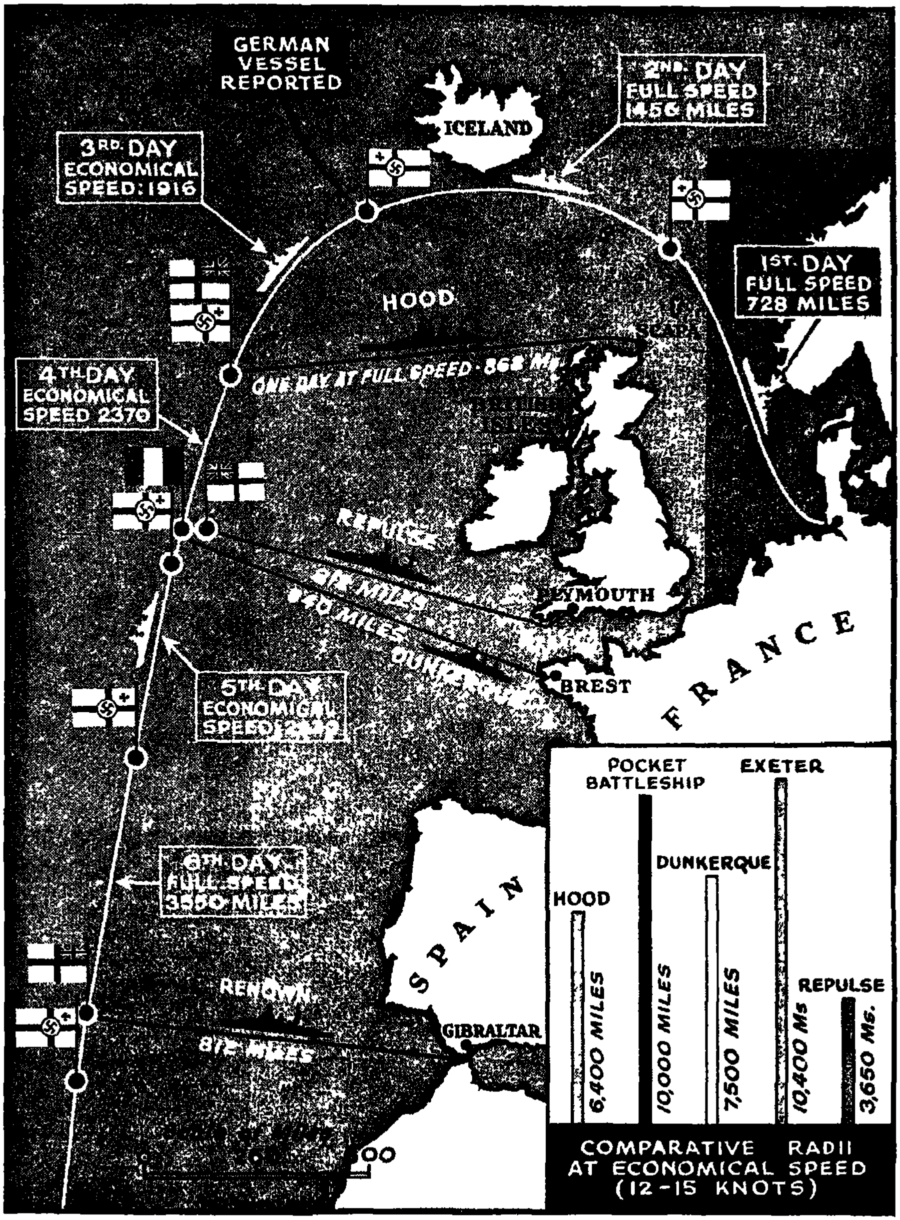
This picture of the battle is provided by what is known as the "plot." On a large table in the plotting room of the flagship are displayed the positions, courses and speeds of all the ships in the fleet. Every order issued by the admiral, every report from any of his ships, and every item of information his aircraft and scouting vessels can obtain about the enemy ships, comes to the plotting room A specially trained staff of officers is responsible for transferring all this information to the "plot," so as to provide an up-to-the-minute picture of the situation. The officers and men fighting in individual ships only know what is happening in that particular area of the battle in which they are engaged, but the commander-in-chief has information about the battle as a whole His orders must be carried out explicitly, no matter how unwarranted they may seem to those commanding separate units

Unlike the commander-in-chief of an army, who works out his tactics well behind the firing line, a naval commander-in-chief is in the thick of the fight and in as much danger as the men he is commanding. On the other hand, his battle is likely to be much shorter

The firing instructions, as well as the manœuvring instructions, come from the plotting room The admiral attempts to bring every enemy ship under the fire of his own fleet. If he failed to do this, some of the enemy ships would be free to direct their fire accurately and unmolested

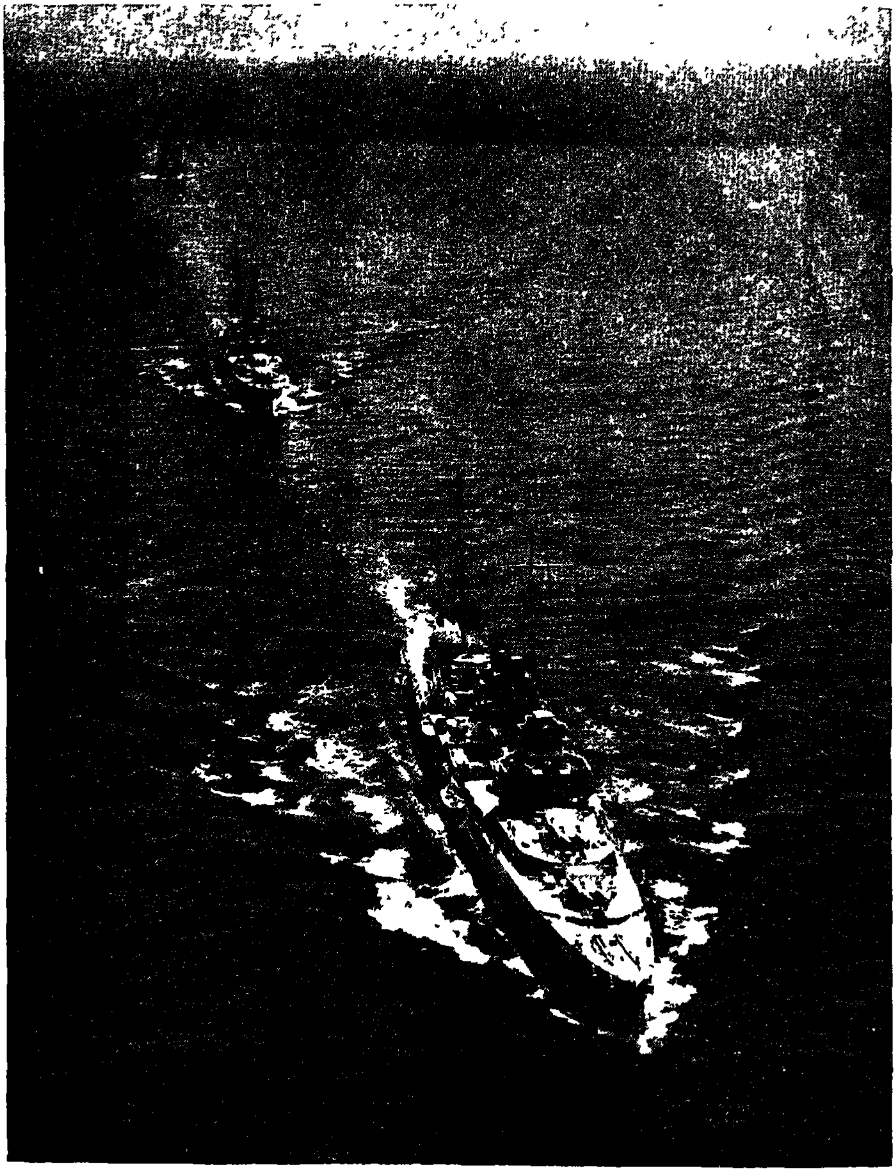
### COMMANDER'S DIFFICULT TASK

Even with the assistance of the "plot," the commander-in-chief's task is an extremely difficult one. His ships, it must be remembered, are rapidly changing their positions, and the picture presented by the "plot" varies minute by minute A fleet is made up of many different types of ships, all of which have particular duties on which their relative positions depend The cruisers are the scouts of the fleet and may be spread out well over the horizon. Their duty is to gain as much information as possible




WHY A GERMAN RAIDER CANNOT OPERATE NEAR BRITAIN

*Comparative speeds of some British and French warships compared with a German pocket battleship Maximum speeds must be carefully distinguished from economical cruising speeds In spite of great range, the pocket battleships lack the speed to escape the fast Allied warships that would operate from Scapa, Plymouth and Brest, should an enemy raider attempt to operate anywhere near the coasts of Great Britain*



SCOUTS OF A BATTLE FLEET

*Three British cruisers in line ahead In a naval action, cruisers act as scouts and are spread out in advance of the main fleet They gain as much information as possible about the enemy fleet, and endeavour to prevent enemy cruisers from getting any information about their own fleet At the same time they are fast enough to maintain contact should the enemy fleet attempt to retreat without fighting Although less heavily armed than the German pocket battleships, British cruisers proved themselves capable of dealing with these craft*

about the enemy fleet and at the same time to try to stop enemy cruisers getting any information about their own fleet. Between the cruisers and the battleships there may be submarines, whose aim it is to deal with any enemy vessels that get past the scouts, when the action is joined, they attack the enemy battleships

The battleships of a fleet will be near the centre of the formation. The destroyers will maintain a protective screen around the battleships until the latter open fire. Destroyers are responsible for warding off submarine attacks, and in


**Fig. 1.** *The two main formations line ahead and line abreast*

action may be required to launch surprise attacks by torpedo as well as to deal with the destroyers of the enemy. When the opposing battleships come within range of each other the destroyers must keep out of the way of salvos from the heavy guns. These would obliterate any small craft they hit.

These are the positions of the ships, and, to continue the analogy of the chessboard, they represent the positions of the chessmen when the game commences. But while keeping them in the same relative positions, the commander-in-chief

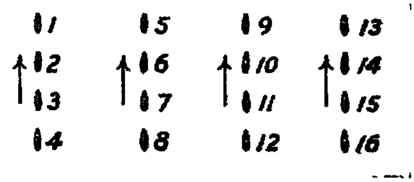



**Fig. 2.** *Ships in combination of line ahead and line abreast formations.*

can change their formation at will

The formations in which ships can cruise, and the ways of changing their formations, are almost innumerable. Many tactical plans for using the formations are secret. A change in formation may take as long as twenty minutes to carry out, so that a great deal of the success of a commander-in-chief may be due to his skill in employing the correct formation at the right moment.

### BASIS OF ALL TACTICS

All formations are variants of the two known as "line ahead" and "line abreast" (Fig. 1). Neither formation is likely to be taken up until the vessels are actually engaged in battle. In line ahead ships are more exposed to submarine attack, but in line abreast fewer guns can be brought to bear on the enemy. To employ all the guns at once the ship must be broadside to the enemy.

When cruising, ships usually take up a formation that is a combination of line ahead and line abreast, as shown in Fig. 2. In this formation they present as small a target as possible to submarines, because from every direction some of the ships are screened by others. At the same time they can quickly change into the line ahead formation for fighting, deploying in whichever direction appears most advantageous. If each of the four ships, following her own flagship, 1, 5, 9 and 13, swings to the left through a right angle they will assume the position shown at (*a*) in Fig. 3. Alternatively

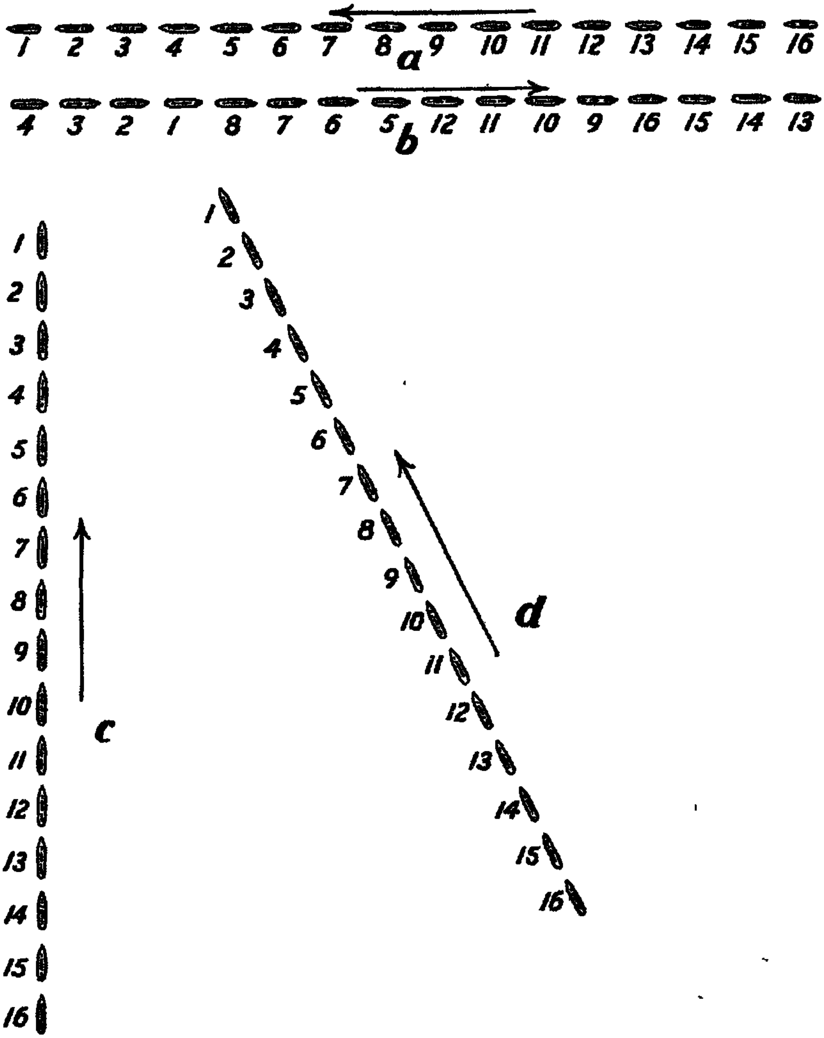



FIG. 3. *Some typical manœuvres of a fleet at sea (see text)*

they may turn to the right and follow No. 13 as the leader in Fig. 3 (*b*). Again, the ships 1, 2, 3 and 4 may continue ahead and those led by No. 5 carry out an S turn, first to the left and then to the right, and similarly with the flagships 9 and 13, until the formation at (*c*) is taken up. Or this manœuvre may be carried out with No 1 making a small turn to the left as at (*d*). Both (*c*) and (*d*) may be performed with No. 13 as the leader. The manœuvre chosen will depend on the relative positions of the fleets and the directions in which they are steaming.

The aim of the commander-in-chief is so to manœuvre that all his own ships can fire at the enemy at the same time,

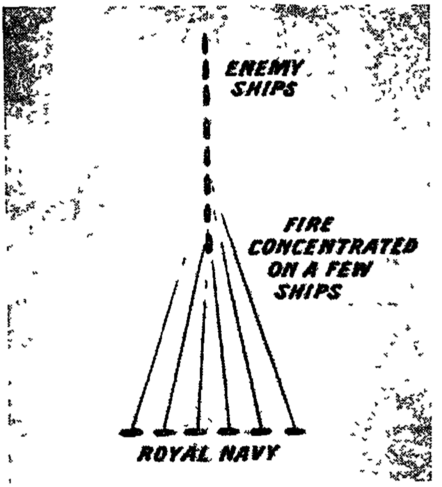



**Fig. 4.** *An enemy fleet out-manœuvred Only the leading ships can effectively return the fire*

while those ships of the enemy that are nearest to him screen him from the fire of those that are farther away If he can do this he is, in effect, putting part of the enemy fleet out of action even before the battle has commenced

The admiral may then concentrate the whole of his fire on the rest of the enemy ships and deal with the others later Such a position is illustrated in Fig 4. It will be seen that by splitting the enemy fleet into two small fleets a large force may be destroyed by a smaller one.

As soon as the enemy admiral sees that the battle is going against him he will attempt to draw off his fleet A retreating fleet has the opportunity of being able to lay mines in the path of its pursuers. It may also attack them with torpedoes When a torpedo is fired at a ship moving towards it, it will obviously reach its mark more quickly than when it is fired at a ship moving away from it Here again the retreating fleet has the advantage, for their torpedoes can be fired at a greater range. If ships are in line ahead when a torpedo attack is made, they turn either their bows or their sterns towards their attacker Thus, if the torpedoes are

LINE AHEAD TO LINE ABREAST

*Battleships in the act of turning from line ahead to line abreast formation The ships are of the "Queen Elizabeth" and "Royal Sovereign" classes*

fired from a position directly ahead, the fleet will keep to its line ahead formation. If they are fired from a position to the right or left, the fleet will turn to line abreast, either travelling towards or away from the torpedoes In this way they present a smaller target.

### FORMS OF SIGNALLING

In order to carry out these complicated manœuvres, the commander-in-chief must be able to transmit orders rapidly and clearly to every unit in his fleet. Various forms of signalling may be used by the ships of a fleet to keep in contact before and during a battle. It might be thought that the advantages of wireless telegraphy were so great that the older forms of flag and semaphore signalling would have become obsolete, but during wartime, flag and semaphore signalling are quite as important as wireless. Under war conditions there are three drawbacks to wireless. It can be heard by the enemy; the apparatus and aerials are vulnerable to gunfire, and it can be jammed by the enemy wireless.

Although wireless messages may be in code, they can still give away the presence of the ships, and before a naval engagement it is essential that the proximity of the fleet should be kept secret from the enemy until the last minute. Smaller vessels are therefore placed between the cruisers to screen the bigger ships. Visual forms of signalling are employed and these smaller vessels receive them and pass them on. Over distances too great for signals by flag or semaphore, messages in Morse code are flashed by signalling searchlights fitted with shutters to cut off the light between the flashes. Instructions from a flagship to the other ships of a squadron are generally given by flag signals.

When the cruisers at the head of the fleet make contact with the enemy they report by wireless. Even then the commander-in-chief will maintain silence The enemy still does not know how far away he is and to use his wireless would be to tell them During an actual battle, wireless must be used as little as possible, because the operators will not only have to send and receive hundreds of reports and instructions that can be transmitted in no other way, but they will also try to pick up the messages wirelessed by enemy ships To enable all these messages to be handled, each type of vessel, from submarine to battleship, employs a separate wave length.

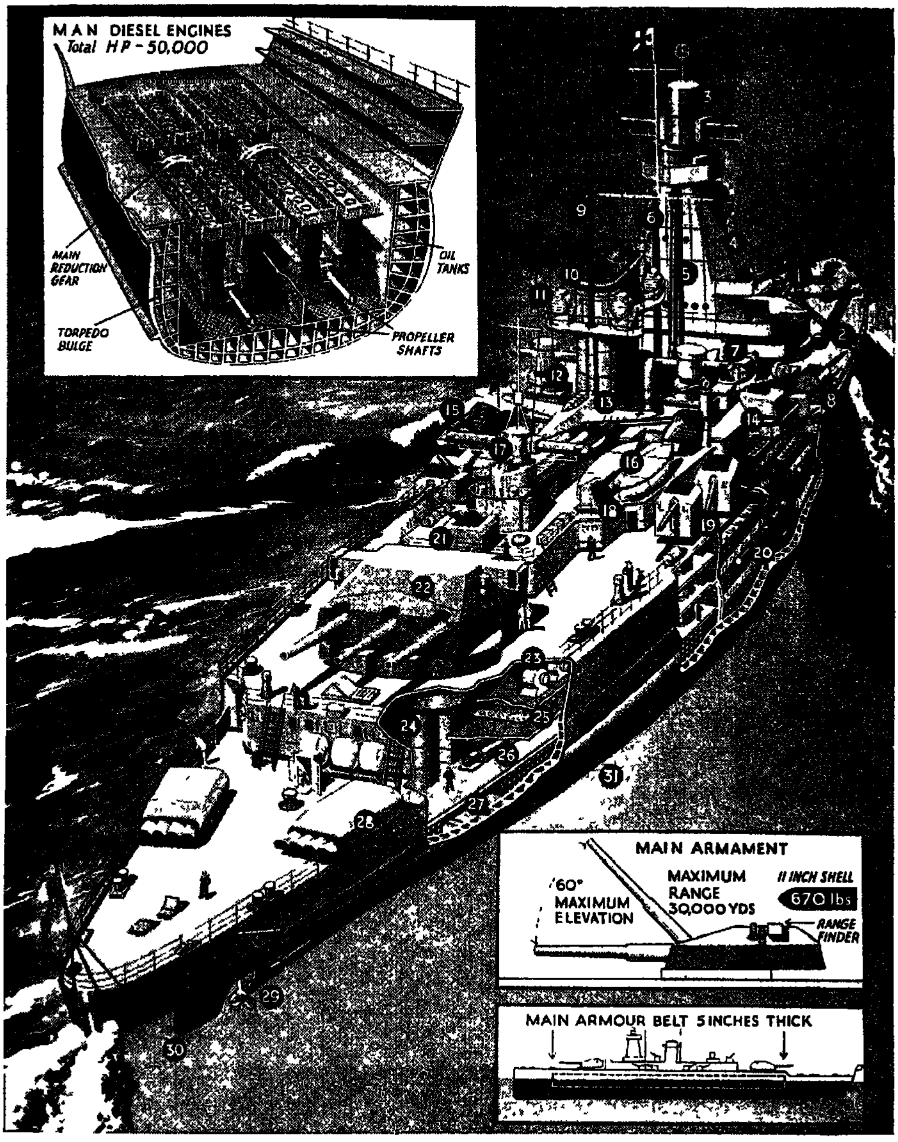
As we have mentioned, a naval battle is the action in which the largest number of warships are likely to be engaged at the same time. But smaller actions may take place more frequently. Cruisers and other warships are engaged in patrolling every part of the sea in which an enemy is likely to be encountered. Instead of sending a fleet to sea the enemy may send out ships alone or in small groups to prey on commerce The main duty of patrolling cruisers is to hunt down these raiders.

Ocean patrol work is mainly carried out by the larger cruisers, which, with an ample fuel supply, are capable of holding their own with any single enemy ship they may meet, short of a battleship. Battleships rarely put to sea unaccompanied by other warships. Should the presence of one be established it is the patrolling cruiser's duty to pass the information by wireless to more powerful British units.

In wartime it is often the unexpected that happens and the cruiser must be prepared if necessary to fight a more powerful force until help arrives.

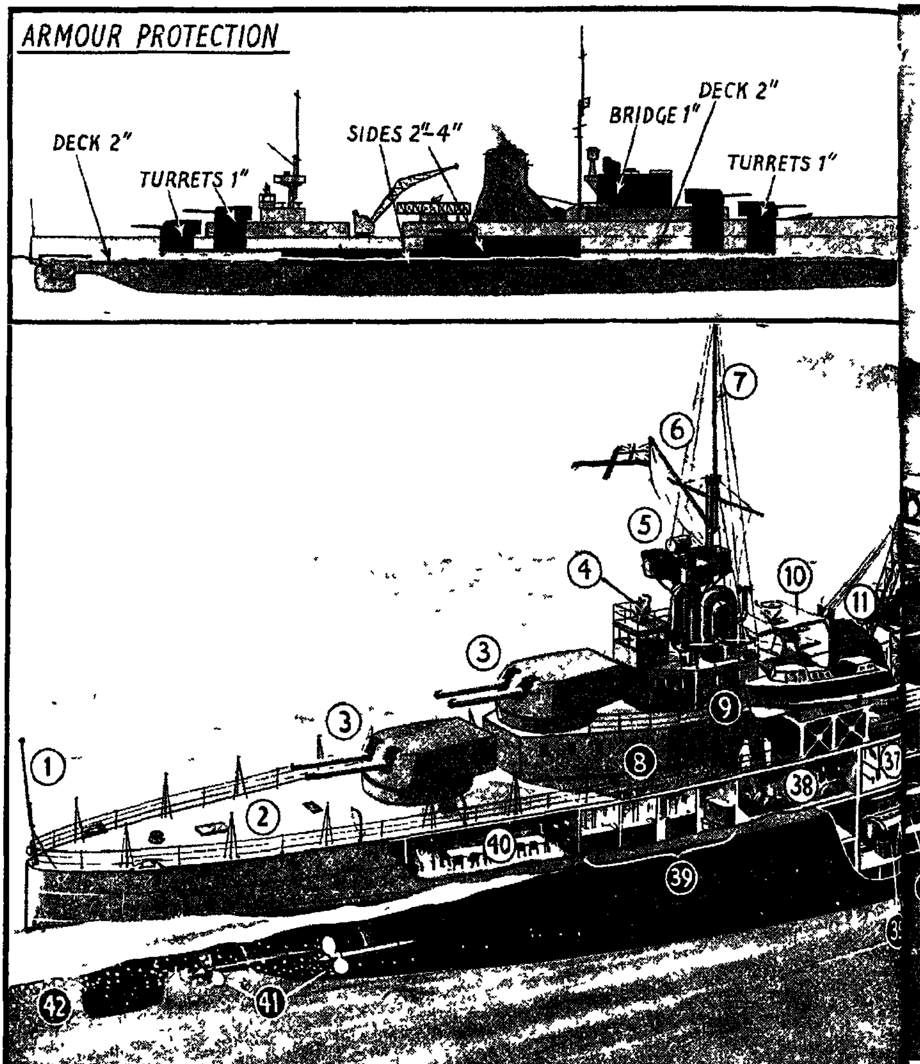
### BATTLE OF THE PLATE

An example was the memorable action at the mouth of the River Plate in December, 1939. The three British cruisers involved were the *Ajax*, the *Exeter* and the *Achilles*, and together




THE GERMAN POCKET BATTLESHIP "ADMIRAL GRAF SPEE"

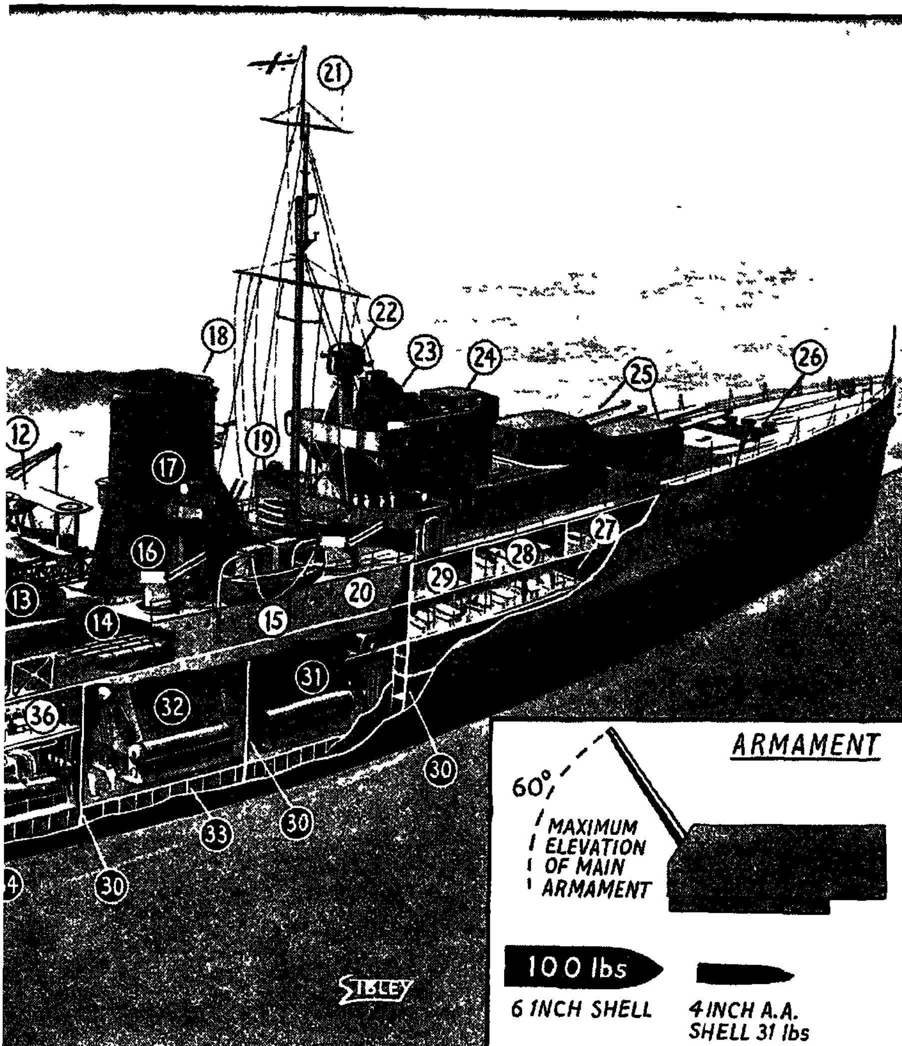
**Fig. 5.** *A sectional view of the German warship scuttled after the Battle of the Plate in December, 1939 1, Capstan gear 2, Breakwater 3, Main fire control and director tower 4, Control tower 5, Boat boom 6, Foremast 7, Admiral's barge 8, Forward 5 9-inch guns 9, Mainmast. 10, Engine exhaust vents 11, Searchlights 12, Secondary armament director towers 13, Aircraft catapult 14, Twin 4 1-inch anti-aircraft guns 15, Whaler 16, Boats 17, After main director tower 18, Three-pounder anti-aircraft guns 19, After 5 9-inch guns 20, Starboard Diesel engines 21, After 4 1-inch anti-aircraft guns 22, After turret of three 11-inch guns 23, Fans 24, Ammunition trunk 25, Wash places 26, Air compressors 27, Magazines 28, Torpedo tubes. 29, Starboard propeller 30, Rudder 31, Torpedo bulge.*




SOME DETAILS OF THE VICTORS OF THE BATTLE OF

**Fig. 6.** *1, Ensign staff 2, Quarter deck 3, "X" and "Y" turrets, two 6-inch guns 4, Multiple machine guns 5, Searchlight platform 6, Gaff 7, Main topmast 8, After superstructure 9, Admiral's barge 10, Spare aircraft 11, Crane 12, Supermarine "Walrus" amphibian flying boat 13, Catapult 14, Starboard torpedo tubes (eight carried in all) 15, Sea boat 16, Twin 4-inch anti-aircraft guns 17, Thirty-six-inch searchlight 18, Streamlined funnel 19, Flag deck with signalling searchlights 20, Twin 4-inch anti-aircraft guns. 21, Mainmast*

they fought and beat the German pocket battleship *Admiral Graf Spee* (Fig. 5) The *Ajax* and the *Achilles* (Fig. 6) each mounted eight 6-inch guns and the *Exeter* six 8-inch guns Their combined broadside (i.e., greatest weight of shell that could be fired simultaneously) was 3,136 pounds, against the *Admiral Graf*




THE PLATE, THE CRUISERS "AJAX" AND "ACHILLES"
*22, Main range finder 23, Main fire control tower 24, Navigating bridge 25, "A" and "B" turrets, two 6-inch guns 26, Capstan and anchor gear 27, Seamen's mess decks 28, Petty officers' quarters 29, Aircraftmen's mess 30, Bulkheads 31, Forward boiler room 32, After boiler room 33, Double bottom and oil fuel bunkers 34, Starboard engine room and turbine 35, Gearing 36, Engine-room artificers' mess 37, Marines' quarters 38, Workshops 39, Officers' cabins 40, Wardroom. 41, Starboard propellers 42, Rudder*

*Spee's* broadside of 4,420 pounds, from six 11-inch and four 5.9-inch guns (Fig. 5). The British squadron was commanded by Commodore H. H. Harwood, in the *Ajax* (knighted and promoted to rank of rear-admiral).

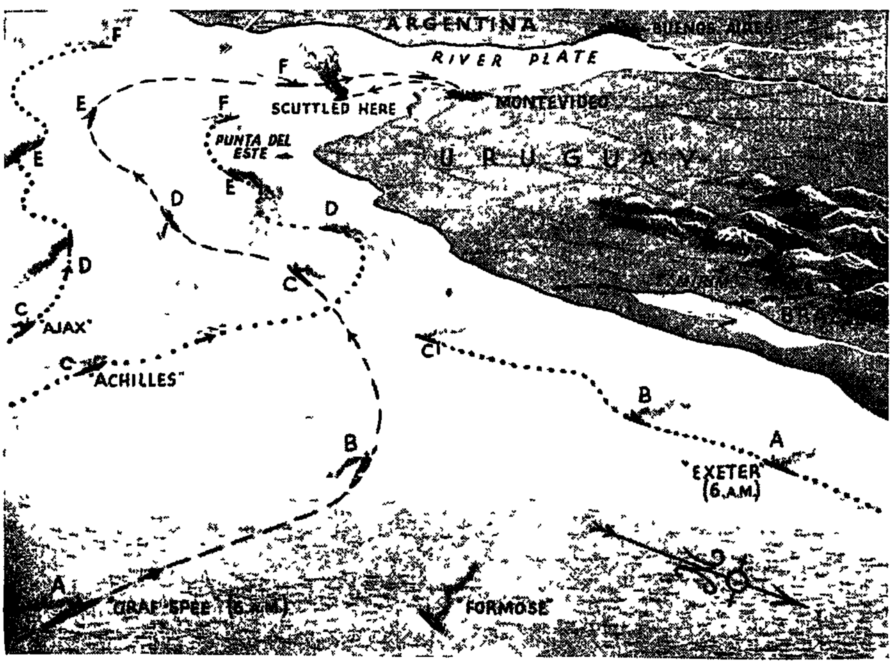
The *Exeter* sighted the *Admiral Graf Spee* cruising off the coast of South

America. She immediately signalled the *Ajax* and *Achilles* that she had sighted the enemy. This was the only signal the three British ships had to exchange throughout the battle, for the tactics which they were to adopt in such circumstances had been carefully rehearsed.

The *Exeter* then prepared to engage the German battleship until the *Ajax* and *Achilles* arrived to help.

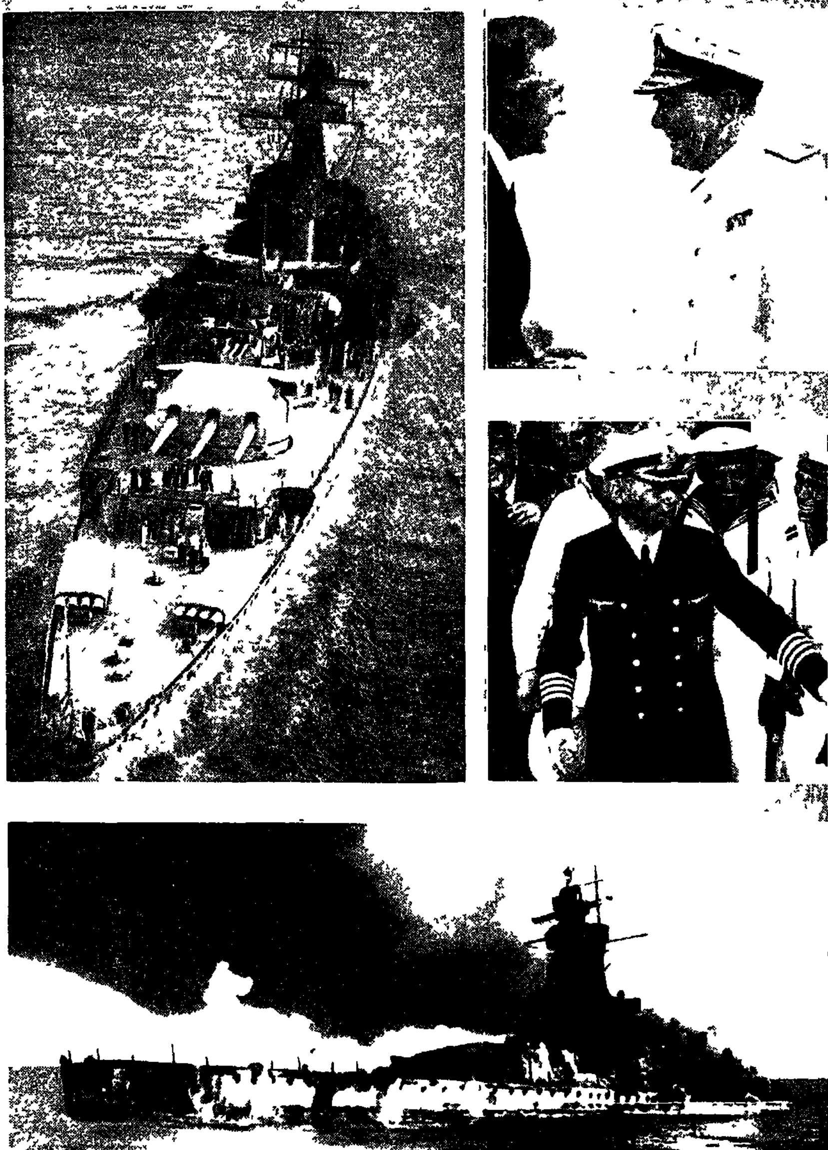
At first, Captain Langsdorff, commanding the *Graf Spee*, attempted to slip away to the south. His business was to raid commerce and to avoid being engaged by British warships But the message sent by the *Exeter* had already warned the other British cruisers and suddenly the *Ajax* and the *Achilles* appeared in the *Graf Spee's* path As they were faster than the German ship they manœuvred so as to force it between them and the Uruguayan coast (Fig. 7)

There was nothing for Captain Langsdorff to do but to take up the offensive, so he opened fire on the *Exeter* with his 11-inch guns. The *Ajax* and the *Achilles* with their 6-inch guns were still out of range and the captain of the *Graf Spee* hoped to destroy the *Exeter* before they could get up to him. Theoretically he should have been able to do this, for his was by far the more powerful ship, but although he inflicted heavy damage the *Exeter* fought on. One 11-inch shell burst close to the *Exeter's* bridge, killing nearly everybody there except Captain Bell, Lieutenant-Commander Smith and a midshipman, none of whom received



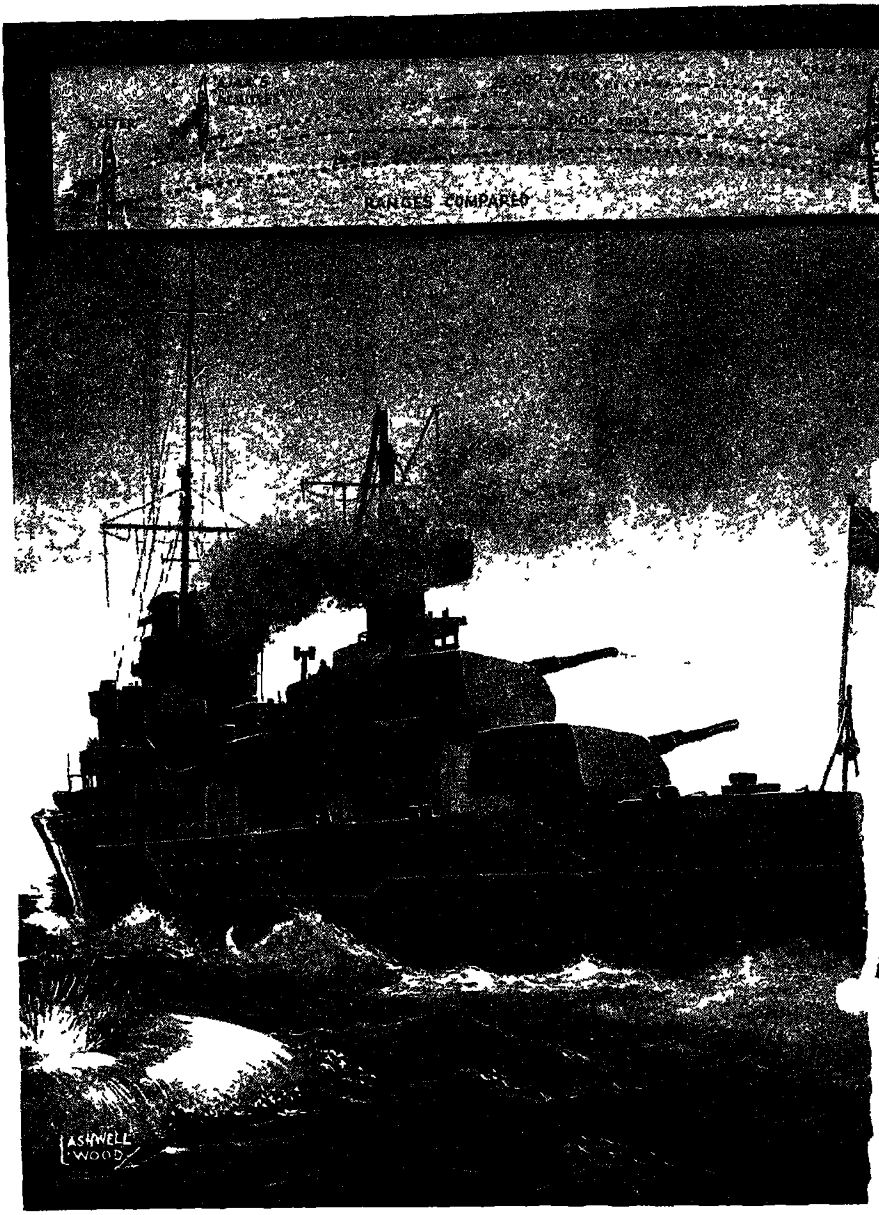

THE BATTLE OF THE PLATE

Fig. 7. *A chart of the approximate courses of the combatant warships At* A, *"Exeter" sights the "Graf Spee" At* B, *the two ships close At* C, *the "Ajax" and "Achilles" approach and the "Exeter" drops out of the hunt At* D, *the "Graf Spee" makes for the open sea, but "Ajax" and "Achilles" close in on each side of her, firing at point-blank range Her further course to the River Plate, where she sought refuge, is marked by* E *and* F



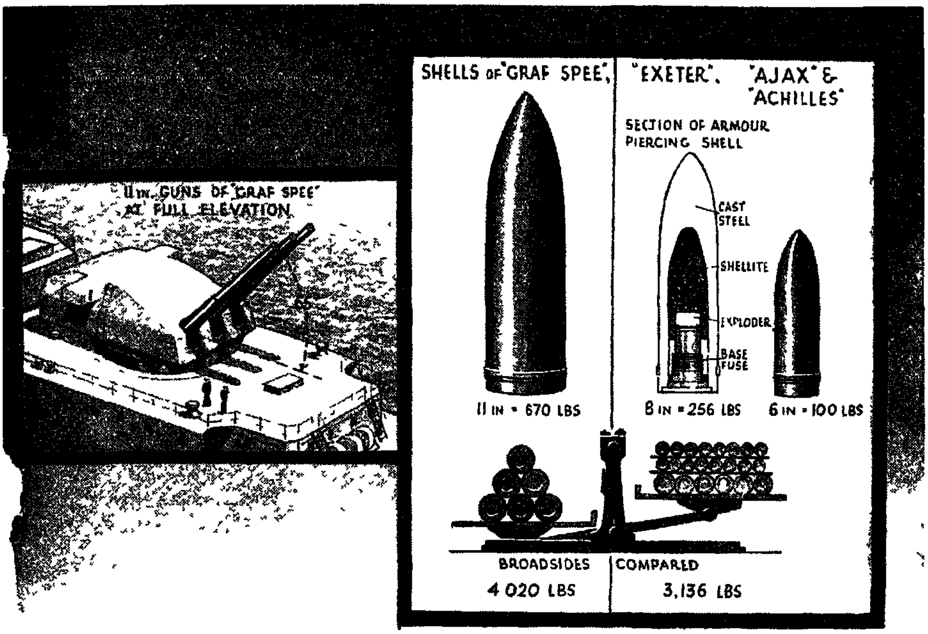
A GLORIOUS PAGE IN BRITISH NAVAL HISTORY

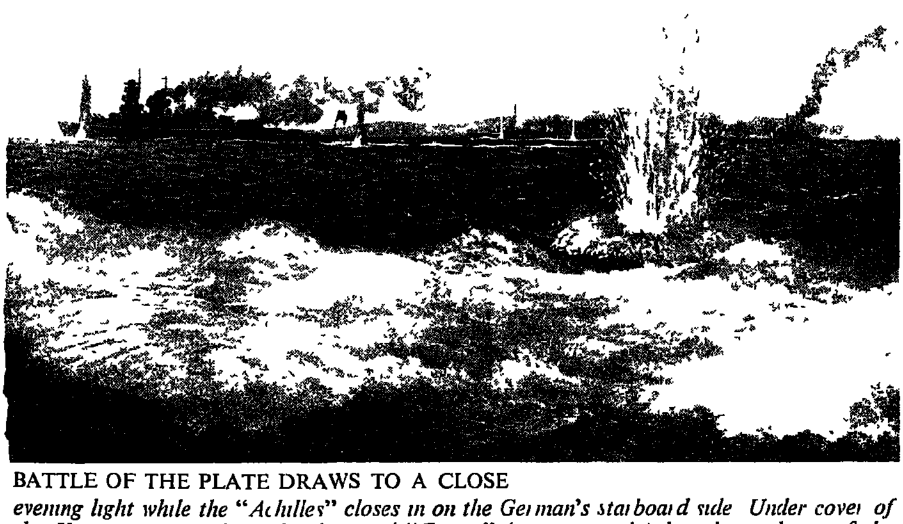
*The story of how three comparatively lightly armed British cruisers—the "Ajax," "Exeter," and "Achilles"—fought and defeated the "Admiral Graf Spee," pride of the German Navy, will remain for all time a landmark in British naval history* (A) *The "Admiral Graf Spee"* (B) *Rear-Admiral Sir H H Harwood of the "Ajax," commander of the British forces* (C) *Captain Langsdorff, the German commander who scuttled his ship* (D) *on Hitler's orders*




"IT WAS A FAMOUS VICTORY"—THE HISTORIC

*This vivid impression—not, of course, to scale—illustrates the final stages of the battle as the sun sets over the South American coast. The British cruisers are seen closing in on the German raider and chasing her to a sanctuary that was soon to become a grave. The "Ajax," in the left foreground, has her mainmast damaged and is about to lay a smoke screen to bother the enemy gunners. She has manœuvred to get the "Graf Spee" (centre), against the*



BATTLE OF THE PLATE DRAWS TO A CLOSE

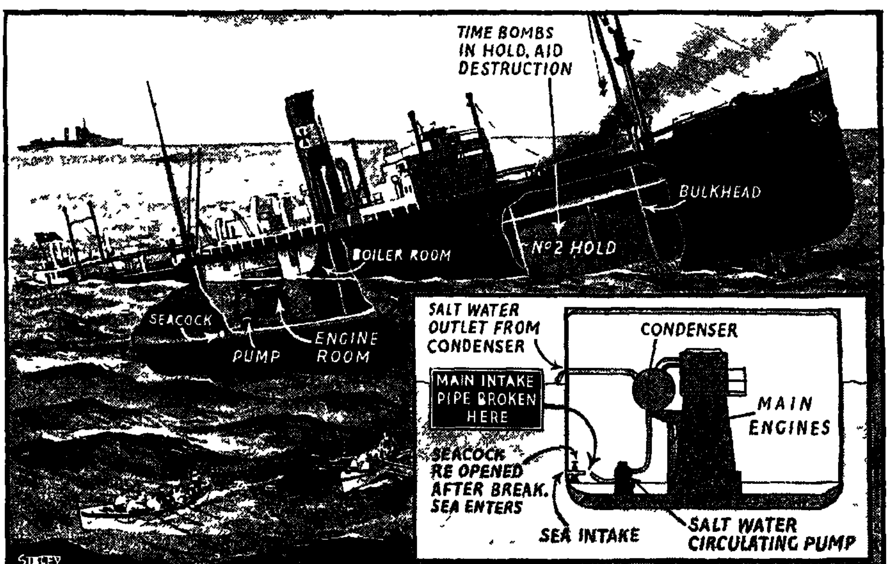
*evening light while the "Achilles" closes in on the German's starboard side Under cover of the Uruguayan coastline, the damaged "Exeter" (extreme right) has dropped out of the chase but lies to the north, preventing escape in that direction (Inset) the respective gun ranges of the combatants (left), the "Graf Spee's" 11-inch guns (centre), and an illuminating comparison of the weight of shell and broadside of the British and German ships (right)*

any serious injury. As all connexion between the after control station and the engine room had been broken earlier in the action, orders had to be passed verbally by means of a chain of seamen. Despite these handicaps, the *Exeter* not only kept afloat but also got close enough to the *Admiral Graf Spee* to bring her own 8-inch guns into action

The *Ajax* and *Achilles* now came within range, and, firing from either side of the *Admiral Graf Spee* they inflicted enormous damage. Captain Langsdorff's ship was by this time in grave danger and his one aim was to break off the action and escape He headed his ship out to sea hoping to separate his antagonists, but this move was foiled The *Exeter*, although so severely damaged that she had lost speed and slipped behind, was still blocking the way to the north Instead of allowing themselves to be separated the *Ajax* and *Achilles* closed in. "With incredible daring," as Captain Langsdorff said, they came tearing through a smoke screen that one of them had laid and got to within a mile of the *Admiral Graf Spee*, firing from either side of her at almost point-blank range

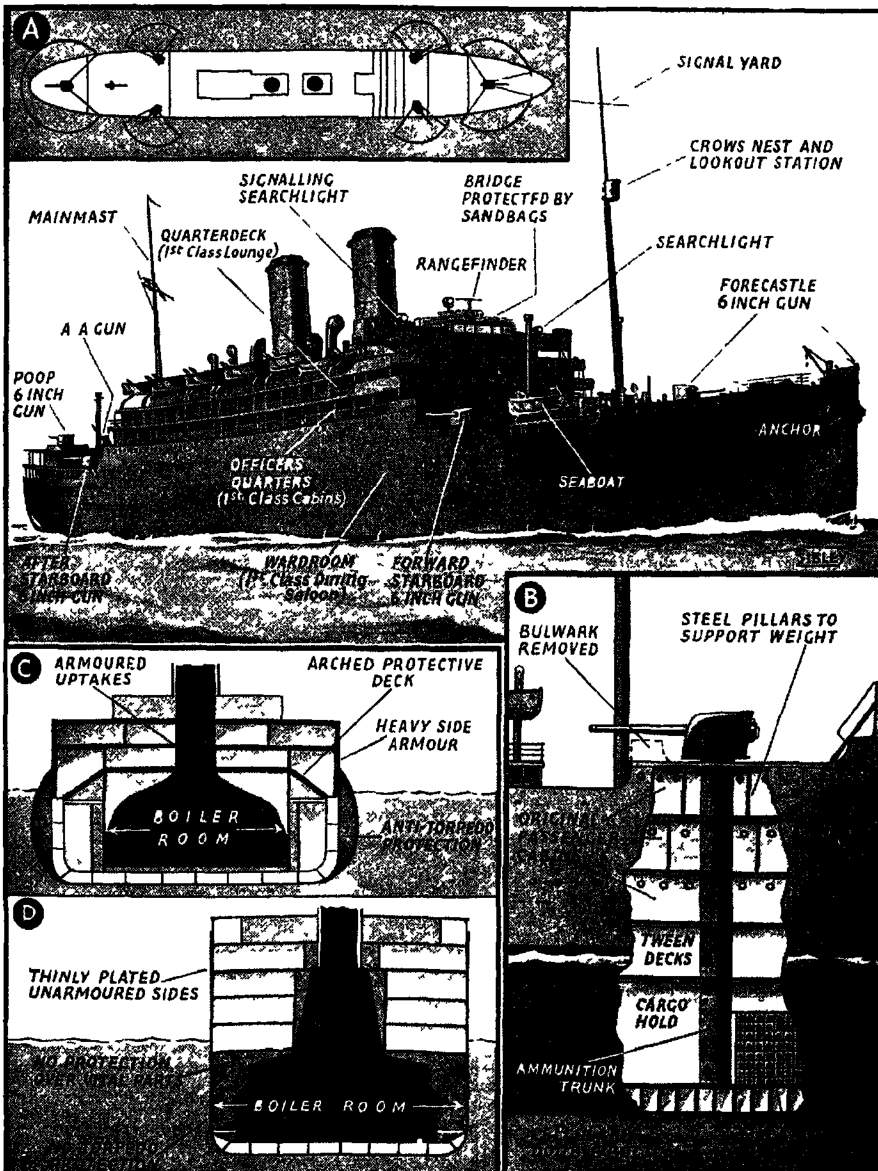
The *Admiral Graf Spee* had taken as much as she could stand, for she turned away to the westward and tried to cover her retreat by means of a smoke screen.

The attack was renewed with the *Achilles* on the starboard quarter of the *Admiral Graf Spee*, and the *Ajax* on the port quarter. About six she was still retreating to the westward, silhouetted against the setting sun, which made her a magnificent target for the two cruisers She turned several times and fired salvos at the British ships, but without effect, her only idea apparently being to get




HOW GERMAN SHIPS ARE SCUTTLED

*All ships use sea water for cooling steam in condensers and for other purposes The main intake is a pipe twenty-four inches in diameter, controlled by a valve or seacock When the ship is to be scuttled this seacock is first closed Then the pipe is broken, the seacock opened again and water pours into the engine room Sometimes time bombs aid destruction*




ARMING BRITAIN'S MERCHANT CRUISERS

**Fig. 8.** *In wartime many merchant passenger liners are taken over by the Admiralty and converted into cruisers. They are chiefly used on the Northern Patrol, as was H.M.S. "Rawalpindi." Some of them are also used in convoy work.* (A) *A plan of the gun positions on a typical converted merchant cruiser, showing the areas of fire.* (B) *Shows how a 6-inch gun is mounted, steel girders between each deck take the strain of its weight. In* (C) *and* (D) *the protective armour of a battleship and a merchant cruiser are compared.*

away from their relentless fire At last it became plain that she was going to enter Montevideo Harbour, but the *Achilles* followed her right into the anchorage to make sure of it.

At the close of the action the *Ajax* had only four and the *Achilles* six 6-inch guns able to fire Buth they were still full of fight, whereas the German was obviously a beaten ship.

Rather than face the British cruisers again, the *Admiral Graf Spee* was blown up outside the entrance to the harbour. This inglorious act, which is believed to have been ordered by Hitler himself, so humiliated Captain Langsdorff that he took his own life as soon as he had seen that his crew were safe

### DESIGN OF POCKET BATTLESHIPS

The signal defeat of the *Admiral Graf Spee* at the hands of three much lighter and less heavily-armed British cruisers raised a number of doubts as to whether the *Admiral Graf Spee* was properly designed. It is interesting to recall, therefore, that the *Admiral Graf Spee*, like the two other so-called pocket battleships, the *Deutschland* and the *Admiral Scheer*, was specially planned to overcome the naval limitations imposed on Germany by the Treaty of Versailles.

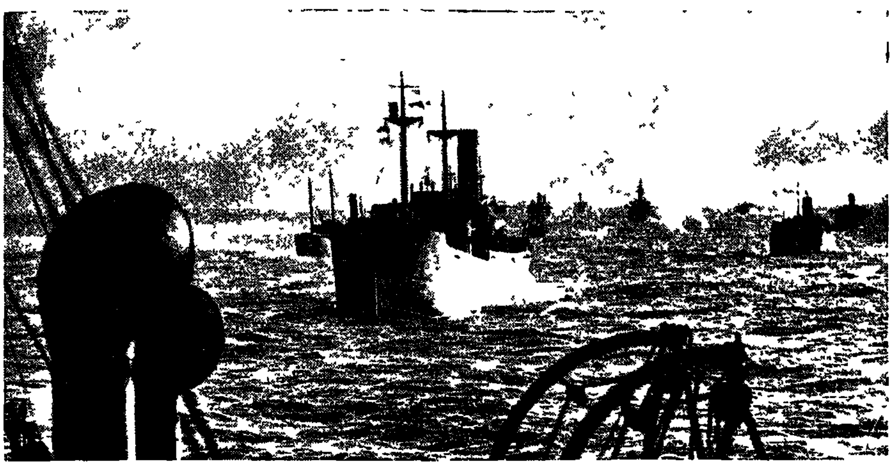
On the design of these vessels, therefore, the utmost ingenuity of the German naval constructors was lavished. The architects set out to build a ship with a very long cruising range that was powerful enough to sink anything that could catch her, and fast enough to get away from anything that could sink her. In fact, the German architects did not succeed in their purpose, but they introduced some revolutionary features into the design of these pocket battleships.

For a start, since the saving of weight was of the utmost importance, electric welding was very largely substituted for riveting. It has been said that over 500 tons in weight was saved in this way. The 11-inch gun turrets and their guns were specially designed by Krupps and are possibly the most powerful naval guns for their size in the world Space, too, was a very important consideration and to economize this, Diesel engines were fitted in place of steam turbines These pocket battleships are reputed to have a radius of action of over 7,000 miles and an average cruising speed of fifteen knots Their top speed is twenty-six knots

One result of these novel features was to make the cost of these ships fantastically high. On the basis of displacement they cost £375 a ton to build. This figure compares badly with the cost of the battle cruiser, H M.S. *Hood*, of 42,000 tons, which worked out at £145 per ton

Such actions as the Battle of the River Plate are all in the day's work for the ships of the Royal Navy that are engaged in patrolling the oceans. The sea routes that have to be protected by the Navy are so extensive that ships other than cruisers sometimes have to be employed. Some of these are large merchant ships taken over by the Navy and converted into warships (Fig. 8). One of these was H M.S. *Rawalpindi*, an ex-P. and O. liner, which played an heroic part in another epic sea fight, this time near the Arctic Circle. The *Rawalpindi* sighted the *Deutschland*, sister ship to the *Admiral Graf Spee*, as she was attempting to slip back to Germany after raiding commerce in the Atlantic The captain of the *Rawalpindi* knew that he was hopelessly outmatched and that help could not be expected for a considerable time. Nevertheless, he joined battle and the *Rawalpindi* went down with her colours flying

Ships of the Royal Navy on patrol are not always expecting to meet an enemy warship They have other work to do. They stop and question ships flying a neutral flag when it is suspected that they



MERCHANT SHIPS UNDER CONVOY PROTECTION

**Fig. 9.** *Steaming in several lines ahead, their speed limited by that of the slowest ship, the trade ships find travelling in convoy a tedious and, at night, a nerve-racking job Yet the system provides the surest protection against submarines and losses are negligible*

may be enemy ships in disguise. If a ship is a genuine neutral she may be carrying contraband, or there may be able-bodied men of enemy nationality on board

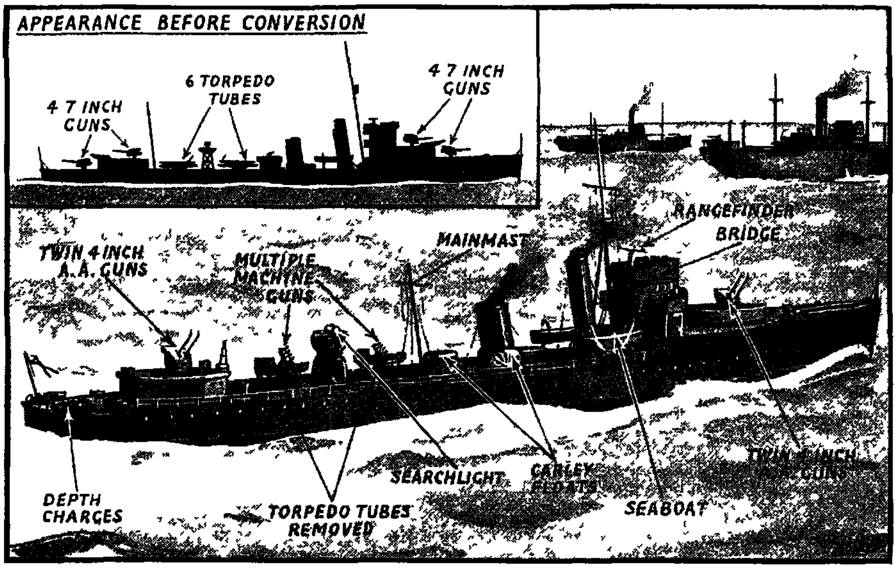
When engaged in such work, the officers of the Navy have to be diplomats as well as sailors. They have to make sure that they do not infringe the international laws of warfare or the acknowledged rights of neutrals When the Japanese ship *Asama Maru* was stopped by a British warship of the China Squadron in the North Pacific it was found that among her passengers were a number of Germans Some of these were removed by the warship The Japanese Government protested at this action, but the British Government was able to prove that the Germans detained were of military age, and that they were on their way back to Germany Once this had been proved the incident was soon settled.

Besides the ordinary patrol work carried out by single warships there is convoy work (Fig. 9). Instead of trying to keep the whole of the seas safe for commerce by intensive patrolling it is much simpler to collect merchant ships together and supply an escort of warships to protect them on their voyages. The effectiveness of this method may be judged by the fact that the percentage of ships lost in convoy through enemy action can be kept as low as one-fifth of one per cent of all those accepting this escort.

### CONVOY AT WORK

The number of destroyers or other warships detailed to protect a convoy depends on the number of merchant ships it contains. Ships requiring protection are given a time at which to be ready to start from a certain port. Here they are joined by the warships and the whole convoy gets into line. Usually the merchant ships steam one behind the other in several lines abreast. The speed of any convoy is necessarily determined by the slowest ship in it. At night no lights may be shown at all, and it is an offence to light a cigarette above deck.

Officers on watch, both in the escorting warships and in the merchant ships




A DESTROYER BECOMES AN ESCORT VESSEL

*The main changes in armament necessary to convert a destroyer into an escort vessel are shown in this drawing Depth charges replace torpedo tubes, 4-inch anti-aircraft guns and multiple machine guns replace 4 7-inch naval guns The ship is equipped with Carley floats*

under convoy, have a difficult job, especially at night. About half-a-mile ahead and astern of each ship, and a few hundred yards on either side, are other ships, invisible in the dark Only by strictly adhering to instructions for course and speed can those responsible for each ship's navigation avoid collisions Even a slight increase in the number of revolutions by the main engines may lead to a collision with the ship ahead, while if the ship moves too slowly, the one behind may crash into her stern Watch must be kept for enemy submarines, particularly in the uncertain light of dawn, when the submarine will have the best chance to approach close enough to the convoy to make sure of a hit before being observed by the escorting destroyers

In any case, it can scarcely be expected that every submarine will be spotted before a torpedo has been discharged The first intimation of the presence of a submarine may be a hit Before the sound of the explosion has died away, blasts on the ship's siren will have indicated that she has been damaged Immediately the other merchant ships in the convoy will scatter, turning their bows away from the direction of attack. As the torpedoed vessel's crew take to the boats, destroyers race to the spot from which the torpedo has come and circle around it, dropping depth charges over a wide area Their guns, and those of the merchantmen will open fire on the submarine should she show herself on the surface Sometimes the bow or stern of the submarine has been seen to rise from the water before finally disappearing, leaving abundant traces of damage in the shape of oil on the surface of the water Then the convoy reassembles and proceeds on its way. If it is not certain that the submarine has been sunk, aircraft may assist in the hunt.

ON THE WATCH FOR RAIDING AIRCRAFT

**Fig. 10.** *Crews manning anti-aircraft guns of a destroyer on patrol The anti-aircraft guns of destroyers operating with convoys are perpetually kept loaded and manned.*

If forced to come to the surface, it can be attacked with bombs and sunk.

Attacks are occasionally made on convoys by aircraft. These attacks develop rapidly and the anti-aircraft guns of the attendant warships are in constant readiness for action (Fig. 10) They are kept pointing skywards, with ammunition handy and gun crews always on the alert. The convoy's best insurance against air attack is the presence of British aircraft in the vicinity, but this is not always possible

By patrol and convoy work the officers and men of the Royal Navy keep open the highways of the oceans in wartime

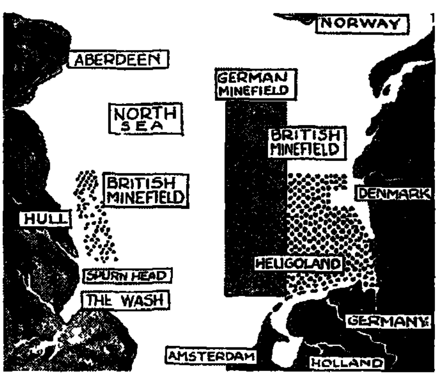



**Fig. 11.** *Distribution of British and German minefields in the North Sea in November, 1939. In wartime minefields are always being extended for strategic purposes*

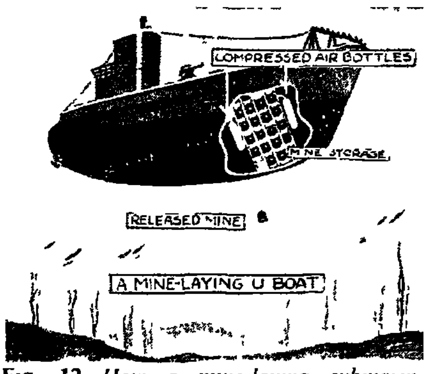
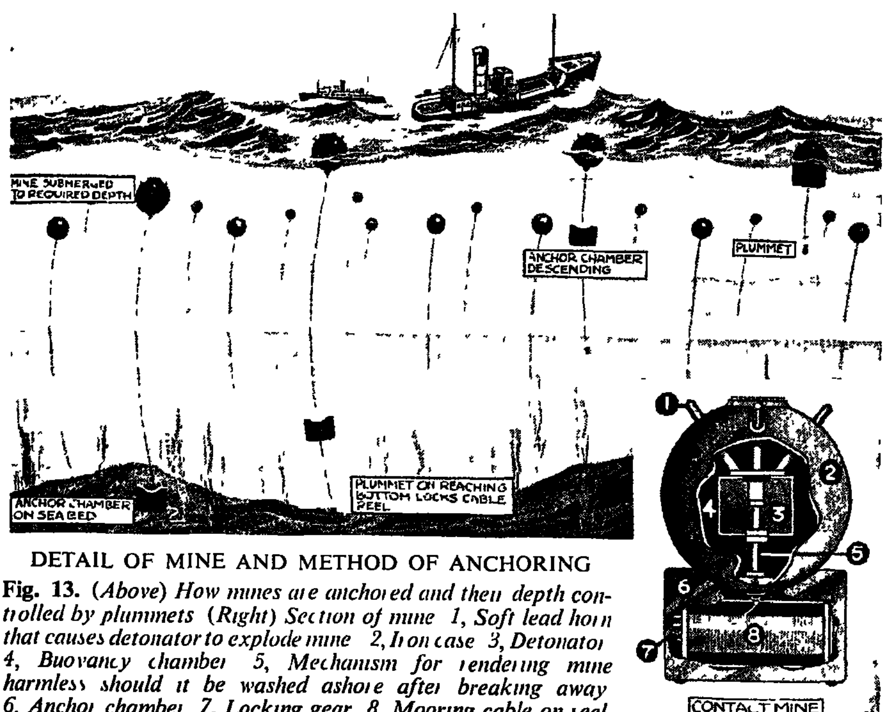



Fig. 12 *How a mine-laying submarine releases mines when under water*

In the narrow seas, when Britain is at war, the men of the Navy risk their lives by night and by day to combat another menace to security—the mine.

Mines play a prominent part in modern sea warfare. In accordance with international law, they may be employed for two purposes. Their first use is to protect home waters and harbours from attack, and their second to blockade enemy harbours and make egress and entry dangerous Nations at war must inform neutral countries where they have placed their minefields (Fig. 11). Mines must be moored and fitted with a safety device that will render them harmless to shipping if they break away from their moorings A floating mine is obviously a menace to neutral ships as well as to ships belonging to countries at war Unfortunately these rules are not always observed

Mines may be laid by surface ships or submarines (Fig 12) and there is also a method of dropping them from aircraft (Fig 14, page 235) Mines are bulky things because they must contain enough air to make them buoyant, besides a heavy charge of explosive. For this reason only




DETAIL OF MINE AND METHOD OF ANCHORING

**Fig. 13.** (*Above*) *How mines are anchored and then depth controlled by plummets* (*Right*) *Section of mine 1, Soft lead horn that causes detonator to explode mine 2, Iron case 3, Detonator 4, Buoyancy chamber 5, Mechanism for rendering mine harmless should it be washed ashore after breaking away 6, Anchor chamber 7, Locking gear 8, Mooring cable on reel*

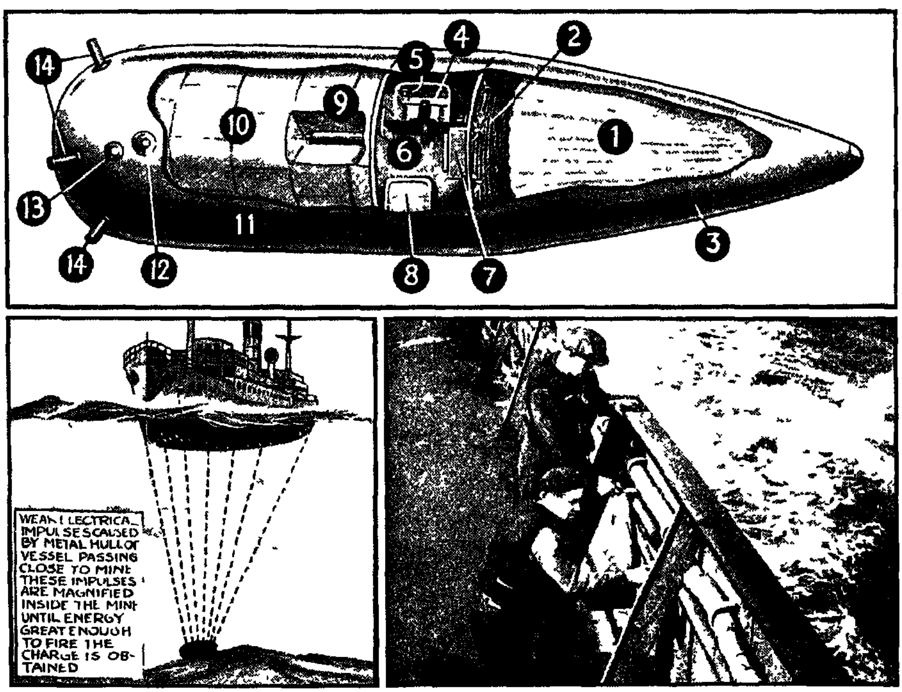
two of the so-called "magnetic" type can be carried by a single aircraft If dropped from higher than a few feet above the sea, parachutes are needed to break the force of their descent into the water. When the mine strikes the water the parachute is automatically detached.

In the case of the moored mine a sinker is attached, this rests on the bottom of the sea to act as an anchor (Fig. 13). The sinker contains a cable reel, and with some types when the mine is lowered into the water it goes to the bottom with the sinker, later rising to within a short distance of the surface This precaution is taken to safeguard the mine-laying vessels from their own mines. In other types a plummet or weight runs down the anchoring cable, the length of which is adjusted so that the mine will float at the desired depth

As mines would be visible if they floated on the surface, the cable is adjusted to keep them at a predetermined depth below the surface

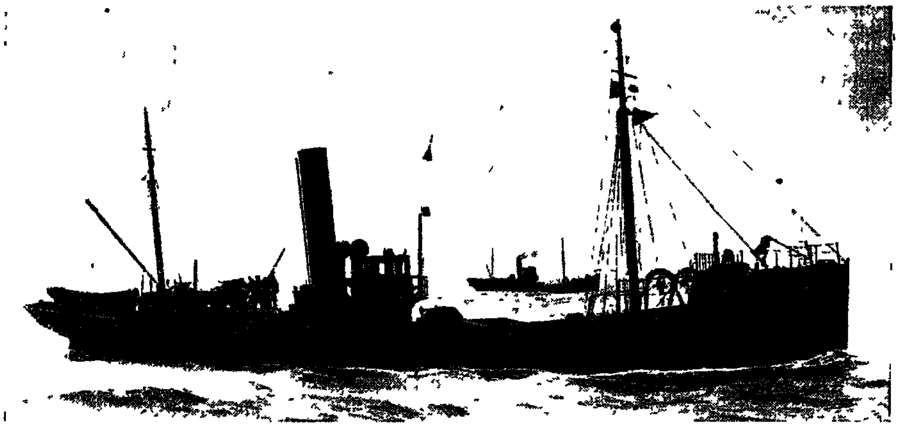
Mines deliberately allowed to drift can be made to stay a given distance below the surface by means of a hydrostatic valve worked by the pressure of the water, in the same way as the valve that controls the depth of a torpedo, referred to in Chapter IX

Mines laid to protect a harbour may be controlled electrically from the shore, so that they remain harmless to friendly vessels entering the port This type is




DETAILS OF THE GERMAN PARACHUTE MAGNETIC MINE

**Fig. 14.** *Top, section of magnetic mine 1, Parachute 2, Parachute ropes 3, Parachute case 4, Magnetic needle 5, Contact 6, Counter weight 7, Relay 8, Battery 9, Detonator 10, Explosive (650 lb) 11, Metal case 12, Impact detonator 13, Hydrostatic valve 14, Horns to prevent rolling Lower left, what happens when a ship passes over a magnetic mine Lower right, equipping a vessel with "de Gaussing" device (see text for details)*



SWEEPING THE SEAS FOR BRITAIN

*Mine sweeping is not only one of the most dangerous of all war jobs, it is also one of the most uncomfortable Mostly converted trawlers, manned by their peace-time crews, these tiny craft carry out their exacting duties in every kind of weather*

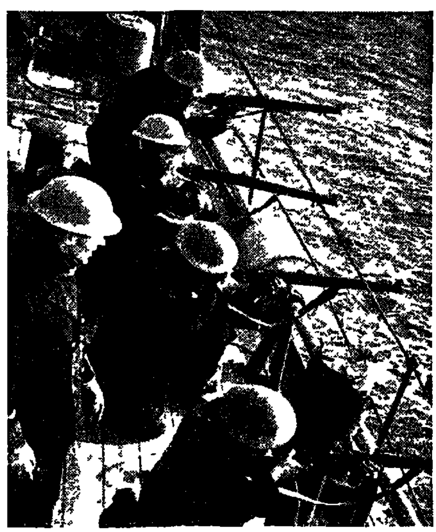
known as a controlled observation mine

Most mines have "horns" projecting from their upper surface These horns are connected with a detonator, so that when a ship strikes one of them the mine is exploded, just as a shell is exploded by a blow on its cap. The so-called magnetic mine will explode without being touched by a ship (Fig 14)

To understand how the magnetic mine works, we must first know something about the magnetic influence of ships It has been discovered that all metal ships carry a permanent magnetic charge that varies according to the place and position in which they were built The detonator of a magnetic mine is worked by a very sensitive magnetic needle As a ship passes directly over the mine, the permanent magnetic charge makes the needle move, and this movement closes an electric circuit thus exploding the mine

Obviously, the simplest way to combat the menace of the magnetic mine is to demagnetize the ship. This can be done by suspending an electrically charged cable around the ship just below the level of the deck This is called "de Gaussing." The giant Cunard White Star liner *Queen Elizabeth* which crossed to New York in March, 1940 was one of the first liners fitted with this device

When it is suspected that mines have been laid in a certain area, minesweepers are sent out to sweep them up and destroy

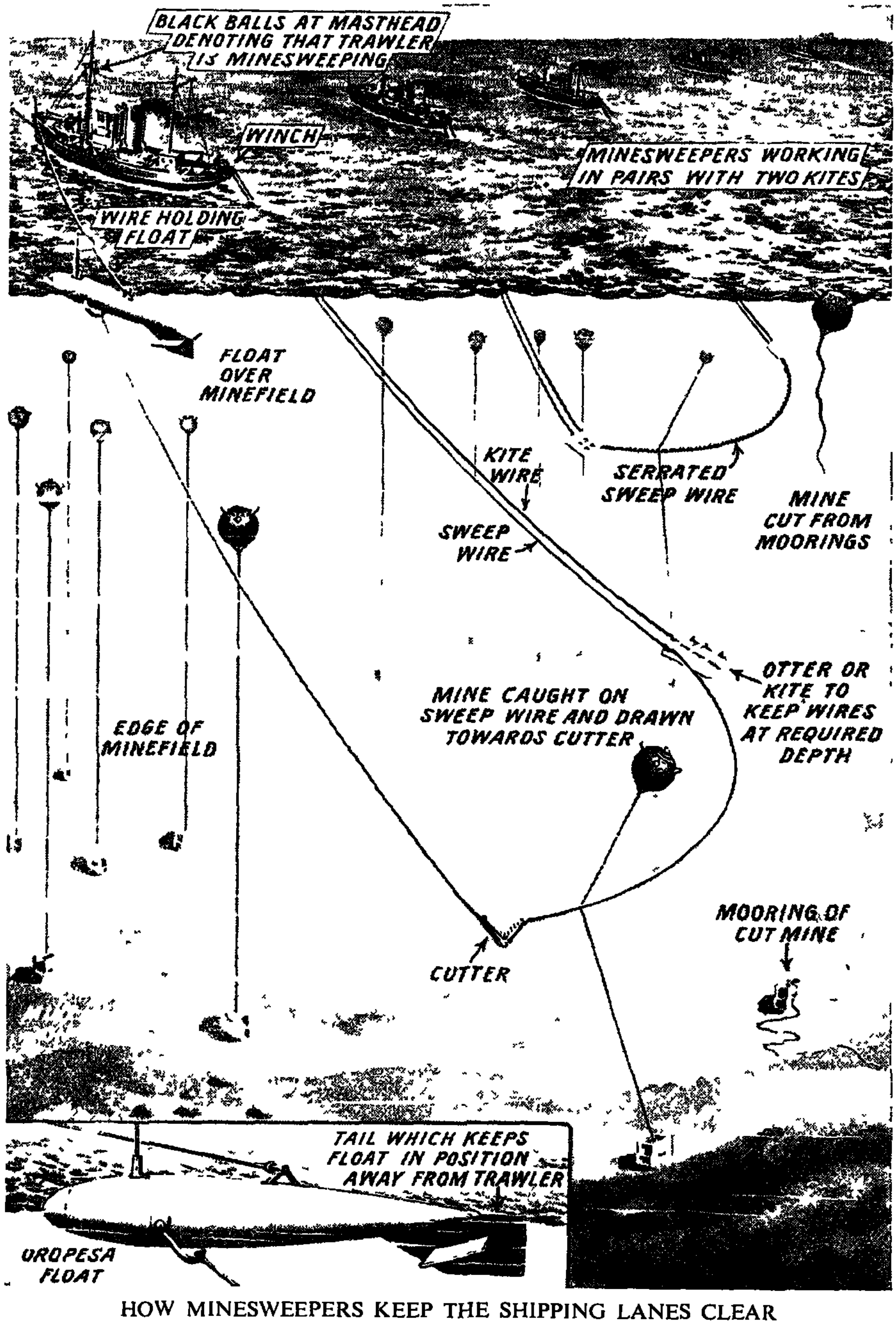


EXPLODING MINES

*Mines cut free by the "sweep" are exploded by rifle fire from the trawler's deck.*

MINES, MINE LAYING AND MINE SWEEPING

(A) *British mines, aboard a minelayer Note their horns* (B) *"Over she goes" A mine dropped overboard from a surface mine-laying vessel Sailors often chalk messages on them like "Have this one with your fish an' chips, Adolf!"* (C) *The kite used by minesweepers working in pairs (see also Fig 15, page 238)* (D) *The paravane, or Oropesa float*




HOW MINESWEEPERS KEEP THE SHIPPING LANES CLEAR

**Fig. 15.** *On the left a minesweeper is working alone On the right are minesweepers working in pairs The Oropesa float (inset, bottom) keeps the wire away from the trawlers.*

them. Sometimes this is done directly ahead of a convoy, but more often it is undertaken periodically over larger areas by ships specially fitted out for the work Many of the ships used for this purpose are converted trawlers, manned largely by their own peace-time crews of fishermen who have volunteered for the work. While other ships naturally avoid channels in which it is known that mines have been sown, minesweepers must enter them deliberately to clear them for traffic. In bad weather the men on the minesweepers are wet and cold all the time they are at sea. Their ship is so small that it requires all their magnificent seamanship to bring her safely through a gale. At the same time, there is always the danger of striking a mine and being blown out of the water. Only men with a great sea tradition behind them could perform this task.

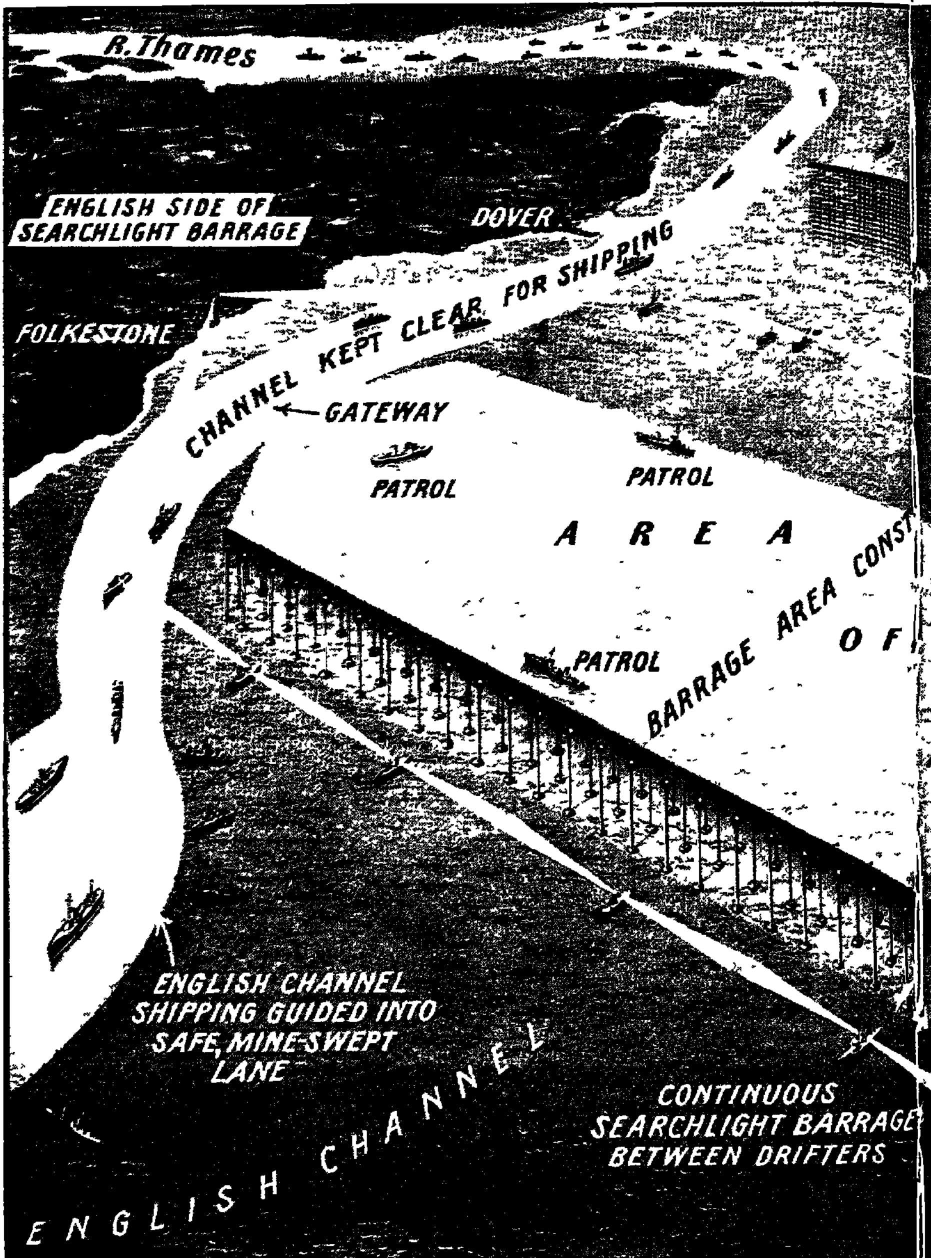
There are two main methods of mine sweeping. In shallow waters a sweep wire is trailed below the surface behind two minesweepers. An arrangement on the wire cuts the mooring cables of the mines and they rise to the surface, to be exploded by rifle or machine gun fire.

The other method can be carried out by a single vessel Wires equipped with a cutting device trail out on either side of the ship's bow. At the ends of the wires are specially designed devices known as paravanes, or, in another form, as Oropesa floats (Fig. 15). They are towed through the water at an angle to the course of the ship and the pressure of the water against them as they move along forces them away from the ship's side. They sink far enough below the surface to pass underneath the mines and the cutting device on the wires to which they are attached cuts the anchoring cables of the mines

As we have seen, the cutting wires trail out from the bow of the ship, so that this is the only part unprotected.

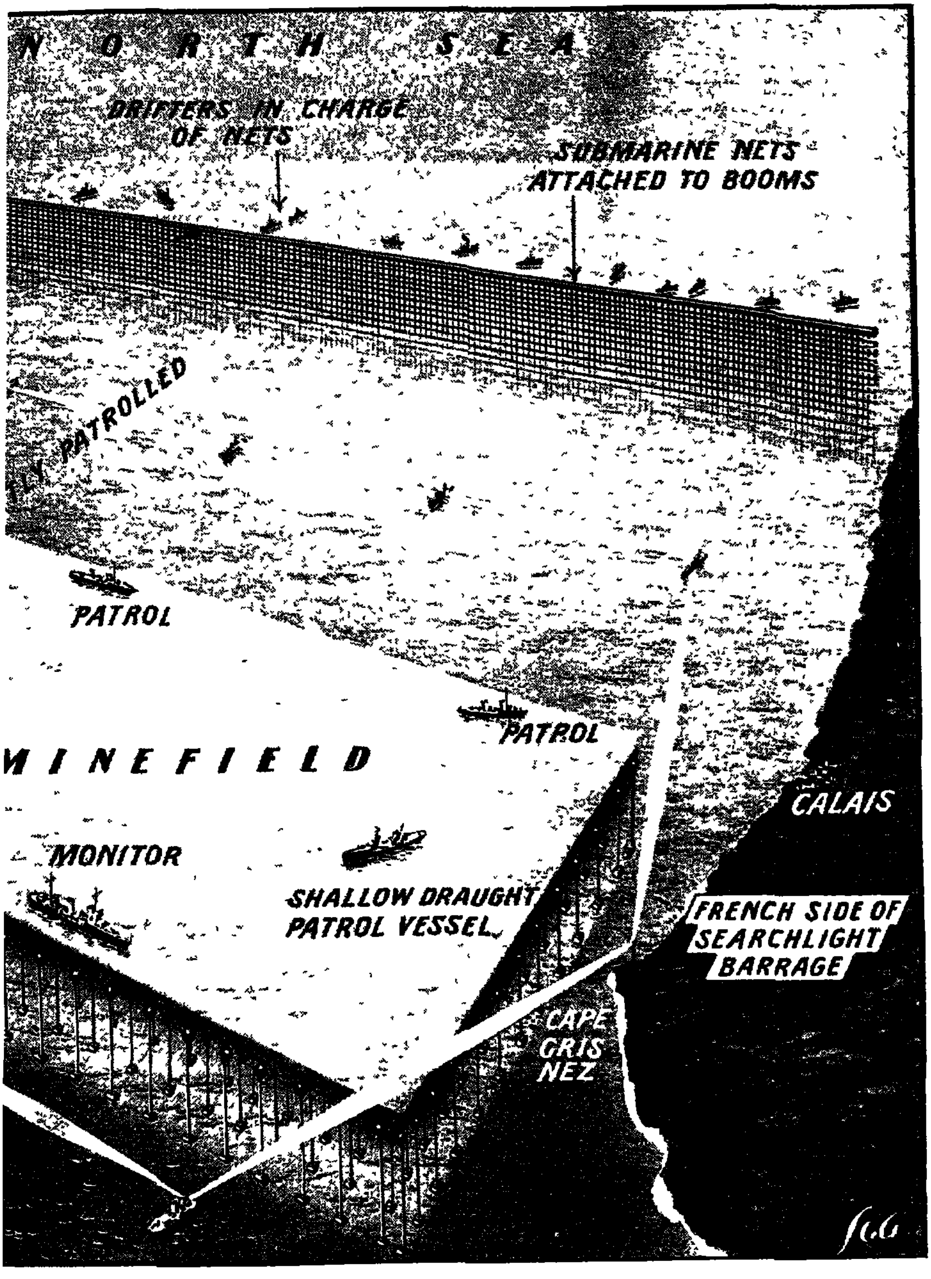
CONTRABAND!

*A barrel of wolfram being removed from the hold of a merchantman under the direction of a Customs and naval officer Great tact and diplomacy are exercised by Britain's contraband control officers, and neutral ships are given every consideration and facility*




HOW THE STRAITS OF DOVER

**Fig. 16.** *Minefields, searchlight barrages, submarine nets and patrol vessels all combine to keep enemy raiders out of the Straits of Dover, as our artist's impression, based on the system used in the war of 1914-18, portrays In wartime much of the English Channel is*




ARE GUARDED IN WARTIME

*closed to ships, and a lane, patrolled and swept of mines, is maintained through the barrage area Allied and neutral shipping is guided into this safe channel Ships suspected of carrying contraband can be directed to a control port where they will be examined*

The danger of a mine striking the bow is remote, since the water pushed forward by the ship as she proceeds tends to swing the mine to one side. Then it slides away from the ship along the wires until it is cut loose A minesweeper flies three black balls at the mast-head when sweeping, to warn other ships to keep clear. The men wear cork life jackets the whole time the work is in progress.

### CONTRABAND CONTROL

Every new weapon added to warfare increases the work of the Royal Navy Mines and submarines are comparatively recent inventions, but one of the latest additions is the economic blockade With this the Navy has more to do than have the other two Services. When Britain is at war, the Navy takes the leading part in the contraband control This prevents supplies reaching the enemy by sea, either direct or through a neutral port, and it may also be operated against enemy exports The actual conduct of the contraband control is, of course, in the hands of the Ministry of Economic Warfare, but the Navy is responsible for much of the work When an economic blockade is in progress it is part of the Navy's duty to see that every neutral merchant ship reports to a control base for inspection. The control bases may be placed at strategic points near sea routes. For example, in the British Isles they have been established at Kirkwall, the Downs and Weymouth. In the Mediterranean, controls have been established at Gibraltar in the west and at Haifa (Palestine) in the east Once the controls have been established, most neutral merchant ships submit to inspection of their own free will to avoid delay, but naval patrols stop any that do not do so The Dover Patrol (Fig. 16) and the Northern Patrol have this added to their work.

When a ship reaches a control base she is boarded by a naval officer with an armed guard The officer inspects the ship's papers and satisfies himself as to the nature of the cargo The ship's papers are then taken ashore and their details telegraphed to London where a decision is made as to whether the ship may proceed or not If everything is in order, the captain is given a code signal that he can exhibit by means of flags to inform any other British naval vessel that his ship has already been passed by the control authorities. If contraband is found the ship is taken into port and the cargo is discharged It can be arranged for "Navicerts" to be issued to a ship in the country of departure These documents are something like passports in that they assure the ship of an uninterrupted passage to her destination, the cargo having been certified as non-contraband.

These are some of the many duties of the Royal Navy in a modern war. Ships may be sent to any of the seven seas, through storms and tempests, fogs and ice Since orders have to be executed, whatever the weather, skilful navigation is essential It will not be out of place, therefore, to include here a short account of the men and instruments that make these multifarious duties possible.

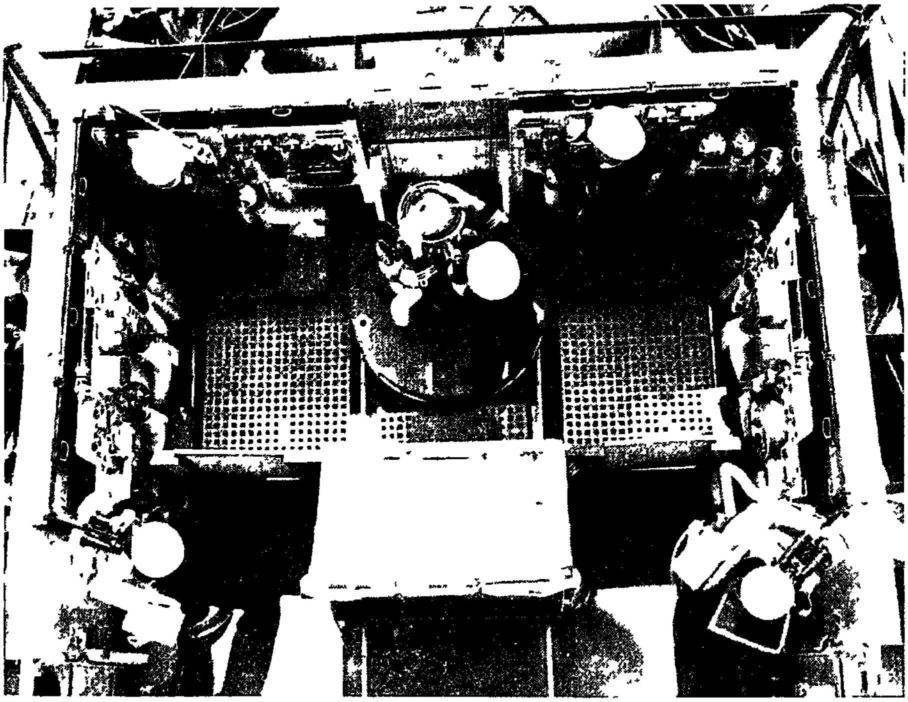
### WORK OF NAVIGATOR

Whatever duties a warship may be performing, her navigating officer (who in a big ship may be aided by an assistant navigator) is an extremely important member of her complement. He must always know the ship's exact position, and must see that all courses set on the chart avoid dangers, such as submerged rocks and sandbanks, and are clear of any known minefields. This work, which is difficult enough even in peace time, is made still more difficult in wartime by the fact that many of the navigation lights round the coast are extinguished.

A warship carries the most modern types of navigating instruments. There


BRITAIN'S MASTERY OF THE NORTH SEA

*Germany's coastline on the open sea is very small, but the Kiel Canal gives her Baltic ports an outlet to the North Sea. Britain, with bases at Scapa Flow, Invergordon and Rosyth, is in a better position. Other British and French bases control the Channel, the Atlantic and the Mediterranean, giving Britain and France strategic superiority over Germany in sea power.*



THE "BRAIN" OF A WARSHIP

*A bird's eye view of the compass platform of a battleship, showing the captain (forward right) and the navigating officer (centre) Other members of the crew keep constant watch*

is the gyroscopic compass that remains unaffected by the ship's magnetism, echo sounders, to measure the depth of water, and, of course, the latest charts and most accurate of chronometers In theory these instruments should make accurate navigation very easy, but in practice the calculations that the navigator makes from them may prove erroneous There may be a strong cross wind blowing tending to drive the ship slightly off her course. There are currents in the water—currents that are not constant, and whose strength, therefore, cannot be forecast. In steering by compass no allowance can be made for these currents and the ship may be set off her course by them.

So the navigator is constantly taking "fixes" of the ship's position He may do this by measuring the angle made by his ship with two points on land. The two points on land will be marked on his chart, and as long as he knows the angle made by the lines joining each point to his ship, he can fix his position exactly. Or he may use the same principle to work out his position by taking the sun or certain stars as his fixed points To measure the angle made by a line joining the sun or a star with his ship he uses an instrument called a sextant together with an accurate chronometer. On the skill of the navigator's work, as on the skill of the work done by all the other members of the personnel, depends the ultimate success of the ship's wartime mission.

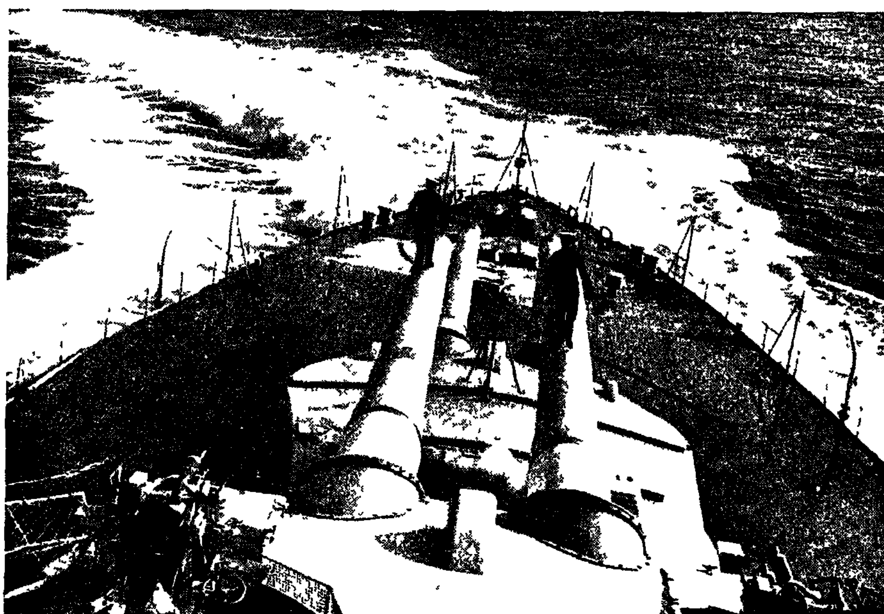
## CHAPTER VIII

# NAVAL GUNS AND GUNNERY

Whether for attack or defence, the principal weapon of a navy is the gun, and the modern ship of war, unless she be one of the smaller special-purpose types such as the submarine or motor torpedo boat, is before all else a floating gun platform. As a general rule, the bigger the ship, the bigger will be her heaviest guns. Indeed, the gradual growth in size of the warship has been very largely due to the recurring necessity for accommodating heavier guns. But this growth cannot go on indefinitely: a point comes when further increase in the size of ships would mean that they would not be able to use existing docks and harbours. These considerations, by limiting the size of ships, limit also the size of the guns they can usefully carry: for the larger and heavier the guns, the bigger must be their floating emplacement.

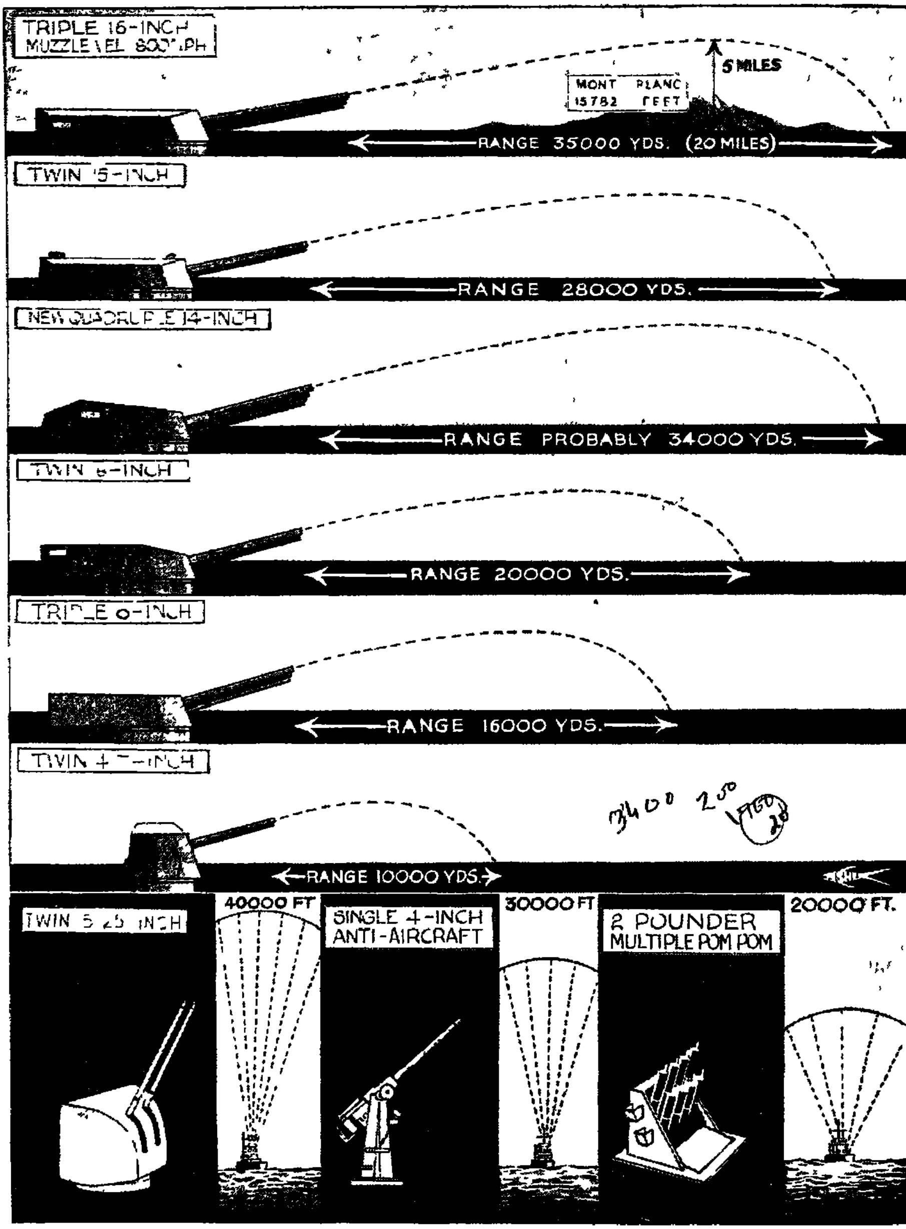
### PLANNING NAVAL GUNS

In deciding on the weight and number of heavy guns that can be carried by a warship of given size, account must be taken of the weight of the ship's essential armour, the speed required and the number and calibre of subsidiary guns. This last factor has become of far greater importance in view of the present-day



FORMIDABLE STERN OF H.M.S. "WARSPITE"

*H.M.S. "Warspite," laid down in 1913, was extensively reconstructed in 1937. Her eight 15-inch guns are carried in four twin-gun turrets. Here are seen the two rear turrets, on the nearer of which are mounted two nests of multiple anti-aircraft guns. This battleship led British destroyers in the successful attack on Narvik on April 13, 1940.*




APPROXIMATE RANGES OF BRITISH NAVAL GUNS

**Fig. 1.** *Guns determine a warship's striking power, and contribute a great deal to her ability to defend herself At one time an 18-inch gun was in use in the Royal Navy, but since the war of 1914-18 the largest gun employed has been the 16-inch, while today the tendency is to build battleships whose primary armament is 14-inch guns All warships are now equipped with varying types of anti-aircraft guns, details of which are indicated in the lower panel*

need for strong anti-aircraft defence, to provide for the increased armament of smaller guns required for this purpose, without sacrifice of speed, the total weight either of the ship's armour or of the heavy guns must be kept down Largely for this reason, although in the war of 1914-18 an 18-inch gun was for a short time in use in the British Navy, the heaviest gun employed thereafter, as in H.M.S. *Nelson* and H M S *Rodney*, both launched in 1925, was the 16-inch, and in the latest battleships of the "King George V" class, 14-inch guns constitute the main armament.

A warship's striking power is governed not only by the size of the guns carried, but by the rapidity with which they fire The bigger a gun, the longer it takes to load, and therefore the longer the interval that must elapse between each round that is fired Only a small percentage of the shells fired from big guns reach their target—it may easily be only one in ten, or even less—and therefore heavier but relatively slow fire may be less effective than firing lighter shells at a rapid rate

### RANGE, RATE AND WEIGHT

Again, the extreme limit of range of a gun depends on the length of its barrel, but the range of the largest naval guns, which is in the region of twenty miles, is already so great as to make really accurate shooting at full range very difficult to achieve.

These three factors of range, rate of fire, and smashing power (or weight of projectile fired) must be considered in the design of every gun, large or small, in relation to its particular purpose, so that the resulting weapon may be based on a compromise in which each may be given its due relative importance, and none unduly sacrificed to another. Fig 1 shows the approximate ranges of the guns in use in the British Navy.

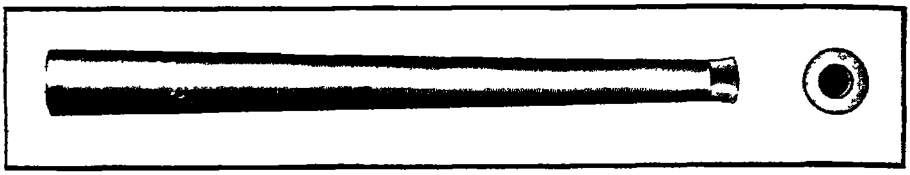
### SIGHTING THE GUNS

Though, as we have seen, their potential range may be greater, naval guns are seldom actually operated at distances greater than fifteen miles, ten miles, indeed, is more common The guns cannot be sighted unless the target is in view, and during an engagement visibility is apt to be reduced to a comparatively short distance, by smoke from funnels, guns, and smoke screens, or possibly by misty or otherwise unfavourable weather conditions. Not only the targets, but the guns themselves will be moving, the ship is constantly altering course, and her roll affects the elevation of the guns. The job of gunnery officer in a modern battleship when engaging an

| CALIBRE (*in inches*) | WEIGHT OF SHELL (*in lb.*) | CALIBRE (*in inches*) | WEIGHT OF SHELL (*in lb.*) |
|---|---|---|---|
| 16 | 2,461 | 5.5 | 82 |
| 15 | 1,920 | 4.7 | 45-50 |
| 14 | 1,560 | 4.5 | 40 |
| 8 | 256 | 4 | 31 |
| 7.5 | 200 | 3 | 12-16 |
| 6 | 100 | 1 (pom-pom) | 2 |

*The 6-inch shell (100 lb.) is the heaviest to be man-handled, all larger shells being loaded by mechanical means.*

***Table showing weights of principal shells used in the Navy today***



HOW THE SIZE OF A GUN IS DESCRIBED

**Fig. 2.** *The diameter of the bore of a gun is called the "calibre" and the length of a gun barrel is expressed in calibres—that is, the number of times calibre goes into length. Thus, a 16-inch gun is forty-five calibres in length, an 8-inch, fifty-five calibres in length, a 4-inch, forty to forty-five calibres in length. This method applies to all guns*

enemy is anything but a sinecure. We shall see, presently, how some of the difficulties are overcome.

Turning now to the types of guns used in the Navy, we may divide them broadly into three classes, heavy, medium, and light, the last including anti-aircraft guns. In the first class come the giants of naval armament—those above 8-inch calibre (calibre is explained in Fig. 2)—which constitute the main power of attack of battleships (Figs. 3 and 4) and battle cruisers. Into the second fall guns from 8-inch to 4.7-inch intended essentially for use against other ships, or, if occasion requires, against land objectives as well.

### MEDIUM AND LIGHT GUNS

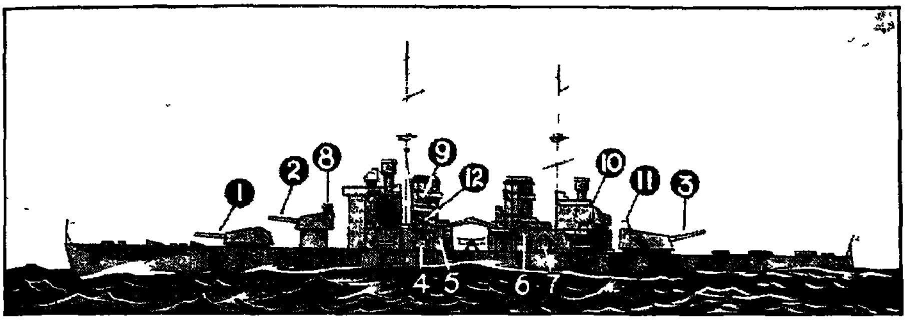
These medium-class guns are employed both as the secondary armament of battleships and battle cruisers, and as the principal armament of cruisers (Fig. 5), destroyers (Fig. 6), and other smaller warships. Those of the third class are mounted in warships of every kind, great and small, and include a variety of interesting types, the lighter ones being mounted in the smallest of all naval vessels.

All naval guns are of the breech-loading type. When breech loading was first introduced difficulty arose in finding a quick method of closing the breech efficiently, and for a time there was a reversion to guns of the old muzzle-loading type. The solution eventually found was based on an idea that, in principle, still holds the field today.

After the shell and firing charge have been inserted, the breech is closed by a breech block — a fully-threaded block into which large longitudinal slots have been cut (Fig. 7). The inside of the breech is correspondingly threaded, and

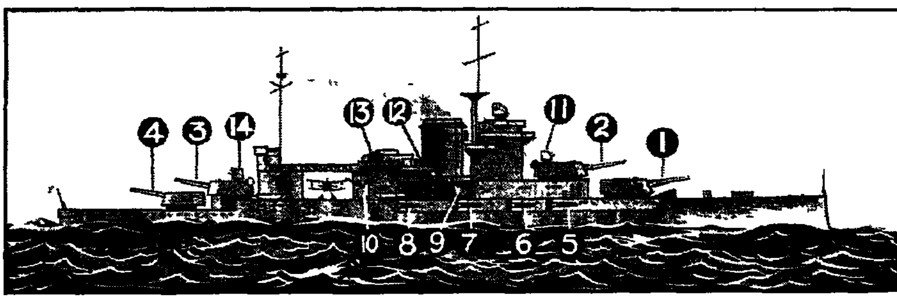
| CALIBRE (*in inches*) | LENGTH (*in calibres*) | WEIGHT (*in tons*) | CALIBRE (*in inches*) | LENGTH (*in calibres*) | WEIGHT (*in tons*) |
|---|---|---|---|---|---|
| 16 | 45 | 103½ | 5.5 | 50 | 6 |
| 15 | 42 | 97 | 4.7 | 40-50 | 3 |
| 14 | (No official figures published) | | 4.5 | 45 | — |
| 8 | 55 | 16½ | 4 | 40-45 | 1¼-2 |
| 7.5 | 45-50 | 13½-16 | 3 | 45 | 1 |
| 6 | 45-50 | 6¾-8½ | 1 (pom-pom) | 40 | 1¾ cwt. |

*Table showing calibre, length and weight of the principal naval guns*



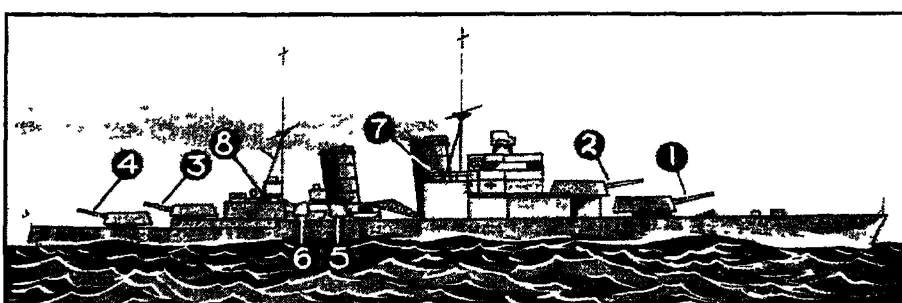

ARMAMENT OF H.M.S. KING GEORGE V

**Fig. 3.** *Armament of one of Britain's latest battleships. The port side is shown. Certain guns are duplicated on the starboard side. Chief armaments are ten 14-inch guns and sixteen 5.25-inch guns. 1, "A" turret, four 14-inch guns; 2, "B" turret, two 14-inch guns; 3, "Y" turret, four 14-inch guns; 4, 5, 6 and 7, Secondary armament twin 5.25-inch guns; 8, 9, 10 and 11, Eight-barrel multiple pom-pom anti-aircraft guns; 12, 4.7-inch high-angle guns.*



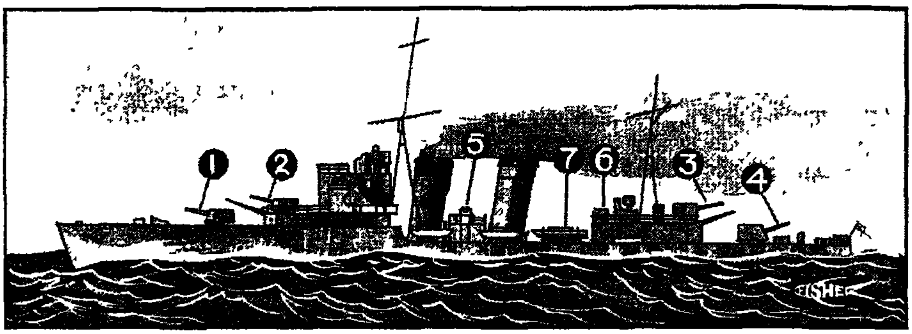

GUNS OF A RECONSTRUCTED BATTLESHIP

**Fig. 4.** *Chief armament of the reconstructed H.M.S. "Warspite" (starboard view). She carries eight 15-inch and eight 6-inch guns. 1, 2, 3 and 4, "A," "B," "X" and "Y" turrets of two 15-inch guns each; 5, 6, 7 and 8, Secondary armament of single 6-inch guns; 9 and 10, Twin 4-inch anti-aircraft guns; 11, Multiple machine guns; 12 and 13, Multiple pom-pom anti-aircraft guns; 14, Multiple machine guns.*




ARMAMENT OF A TYPICAL BRITISH CRUISER

**Fig. 5.** *This picture shows H.M.S. "Southampton" (starboard view), whose main armaments are twelve 6-inch guns. 1, 2, 3 and 4, Turrets of three 6-inch guns; 5 and 6, Twin 4-inch anti-aircraft guns; 7, Multiple pom-pom anti-aircraft guns; 8, Machine guns.*

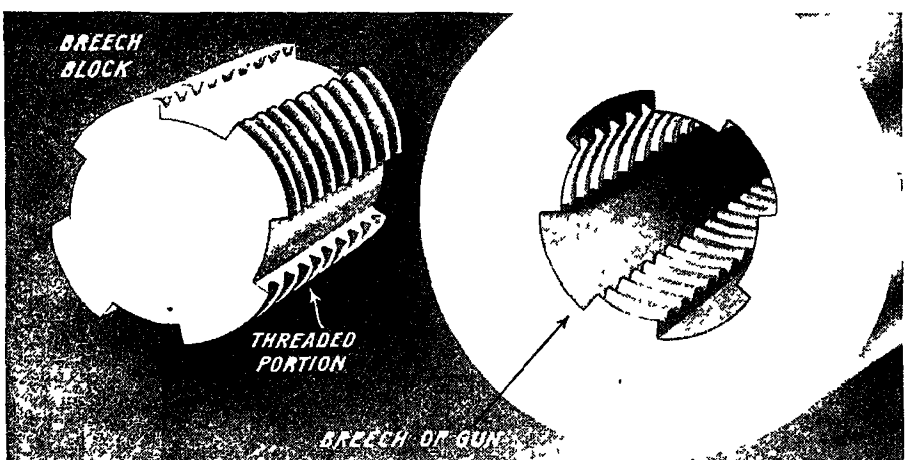



ARMAMENT OF A TRIBAL CLASS DESTROYER

**Fig. 6.** *Destroyers of this class (port view) carry eight 4·7-inch guns 1 and 2, Forward 3 and 4, After twin 4·7-inch gun turrets 5, Multiple machine guns 6, Multiple pom-pom anti-aircraft guns 7, Four 21-inch torpedo tubes*

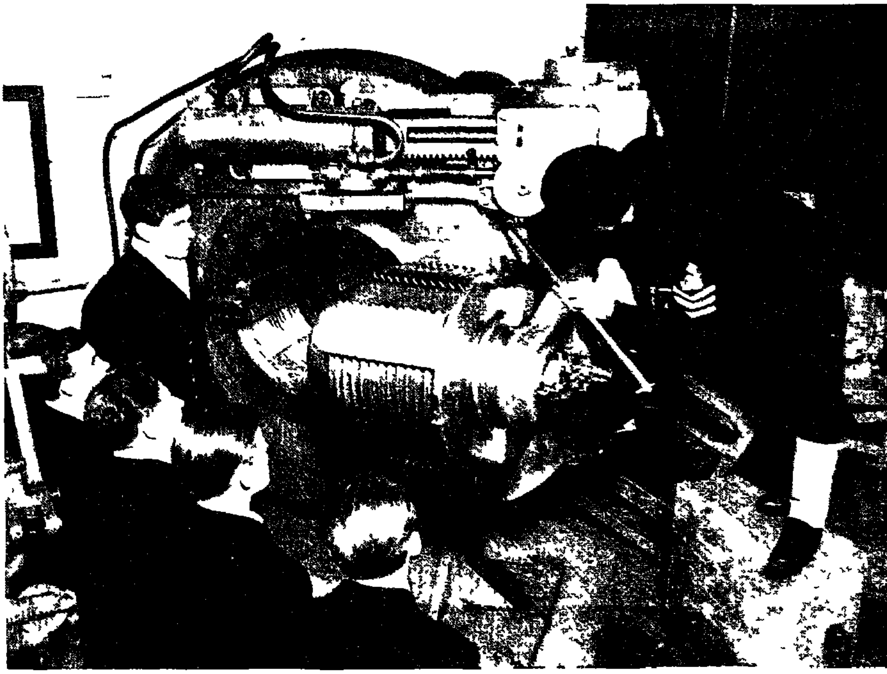
across its thread similar longitudinal slots are cut to permit the threaded parts of the block to enter, locking the breech on the screw principle. The breech block can thus be pushed home quickly in one movement It is then given a partial turn, so that the male and female threads are engaged and the block held securely in place The principle is illustrated in the diagram, though for the sake of simplicity the full details of the construction of the breech and block have had to be omitted

The biggest of heavy naval guns, the 13.5-inch, 14-inch, 15-inch and 16-inch, are mounted in twos, threes, or fours, in power-operated gun turrets. The four-gun arrangement, a comparatively recent innovation, is found only in the latest vessels. Some dispositions of guns are shown in Figs. 8 and 8a. The ten 14-inch guns of H.M.S. *King George V* are mounted in two four-gun turrets and one two-gun turret. When two turrets




SIMPLIFIED DETAIL OF BREECH BLOCK

**Fig. 7.** *The breech block is really a threaded block into which longitudinal slots are cut The breech itself is correspondingly threaded and slotted The breech block can thus be inserted into the breech and locked by a half turn.*

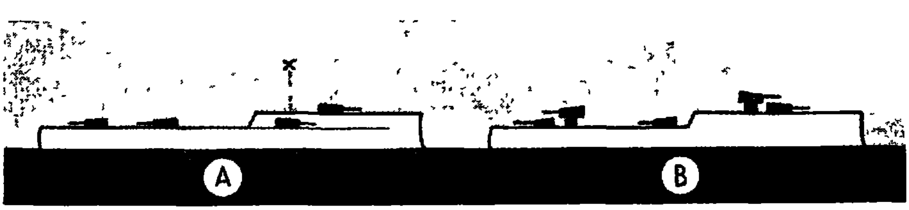


BREECH OF A NAVAL GUN

*A class of sub-lieutenants at H M Gunnery School, Whale Island, receive a lecture from their instructor on the mechanism of the breech of a 15-inch naval gun*

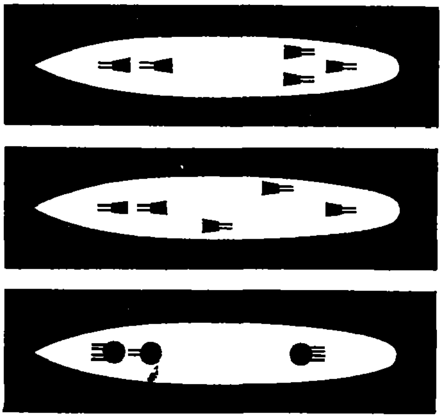
are close neighbours, one is on a higher level than the other and behind it so that the guns may fire clear of one another (Fig 9)

When the guns are moved, the whole turret, with the gunners and the shell-supply mechanism, turns with them. The turrets are operated by hydraulic power, which is also used for loading the guns The shells can only be manipulated by power, for each shell may weigh a ton or more From below the platform on which the guns are mounted, a large steel tube runs down through the ship This tube is fixed, but within it is a second tube, attached to the gun platform, and rotating with it. This second tube passes down to the magazine and shell rooms of the ship, which are situated at the bottom of the hull Shells




METHODS OF GUN MOUNTING

**Fig. 8.** (A) *Early method of mounting five turrets, with one wing turret* (X) *on either side This has given way to the superimposed types of mounting shown in* (B)



ARRANGEMENT OF GUN TURRETS

**Fig. 8a.** *(Top) Turrets giving broadside of eight guns (Centre) Turrets "en echelon" giving broadside of ten guns This arrangement has the disadvantage of cross-deck firing which strains the ship (Below) Modern arrangement (as in "King George V" class of battleship) with all turrets on centre line, giving full gun power on either beam*

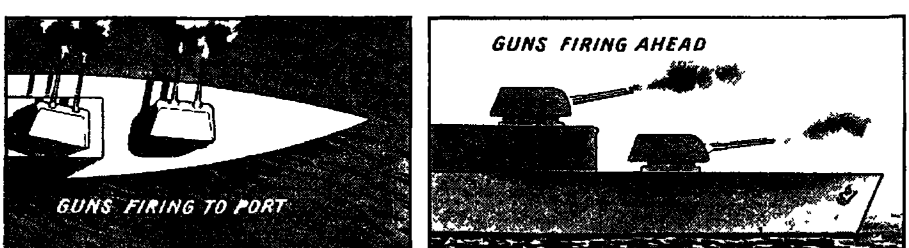
and charges are conveyed by means of overhead conveyers to the foot of the tube, loaded in, and raised by power to the gun level Since the tube turns with the guns, the shells do not need to be turned again when they reach the top of the tube, but are already in the correct position for loading. Details of the construction of a gun turret are seen in Fig. 20, page 267

The ammunition used for all big naval guns is in separate parts, the charge, which forces the shell from the gun, being separate from the shell itself, and inserted in the breech by a distinct operation, made necessary by the weight involved. The 16-inch guns of H.M.S. *Nelson* (Fig 10), for example, fire shells each of which weigh 2,460 lb.—well over a ton—and the weight of the charge is 640 lb. It is obvious that if these weights were combined, and the shell and the charge made in one, as with the brass-cased shells of small guns, the ammunition would become so heavy that it would be very difficult to handle.

The charge used for heavy naval guns is cordite—a mixture of nitro-glycerine and gun cotton dissolved in acetone, and stabilized by adding a small proportion of vaseline. Cordite gets its name from the fact that it is prepared in the form of thick cord-like threads. The charge of cordite is contained in a bag of pure silk: this material is used because, when consumed in the explosion, it leaves no residue to foul the breech.

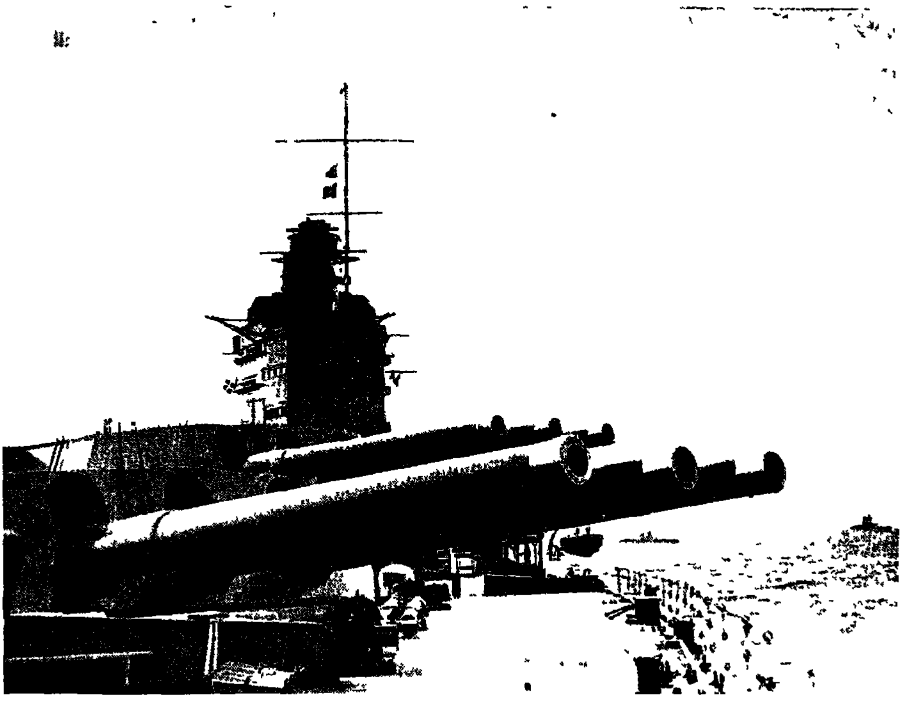
**HOW A GUN IS FIRED**

Behind the cordite charge a little tube containing a small quantity of gunpowder is placed to assist the ignition, for cordite does not take fire readily. The gunpowder is electrically ignited by means of a fine wire inserted in the




ELEVATION AND SWIVELLING OF GUN TURRETS

**Fig. 9.** *This diagram shows that when two gun turrets are close together, one is mounted at a higher level so that the guns in one turret are clear of the other if firing in the same direction (right) When the guns are firing to port or starboard the whole turret swivels round (left)*

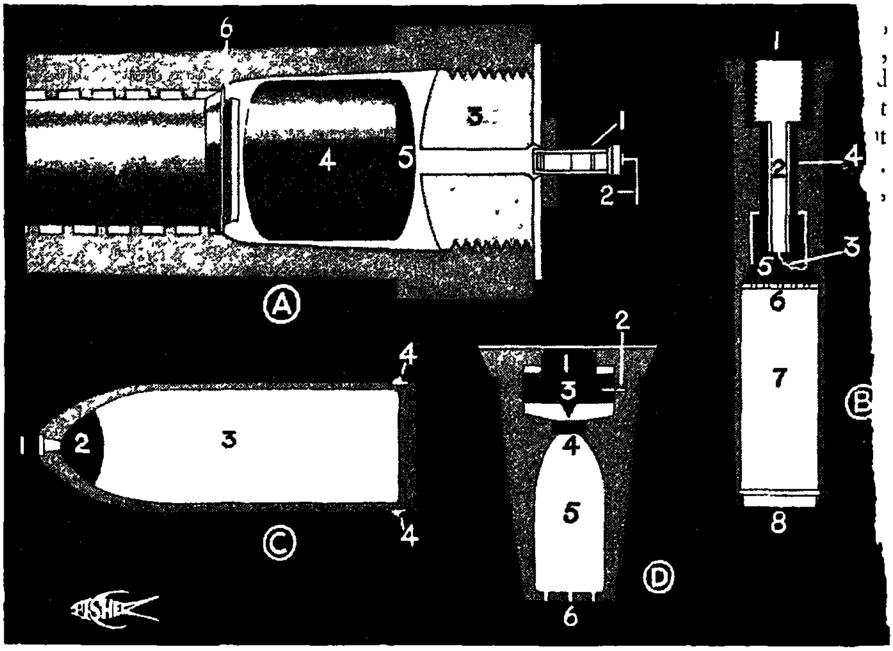


TRIPLE-GUN TURRETS OF H M S NELSON

**Fig. 10.** *The big guns of a modern warship are today mounted in threes or even fours in one turret Here can be seen six of the nine 16-inch guns mounted in triple-gun turrets by H M S "Nelson" This method of mounting economizes space and weight*

tube. When the trigger of the firing pistol is pulled, this wire glows white-hot, thus igniting the powder, which in turn fires the cordite (Fig. 11)

A question often asked is, why the barrels of long-range guns are always so long themselves To answer this question, let us consider what happens when a gun is fired. When the charge of cordite is fired, a tremendous amount of gas is given off. Since the breech and barrel of the gun and the base of the shell confine this gas to a small space, it is greatly compressed and its natural tendency to expand exerts tremendous pressure. This expansion, and the pressure that results from it, is immensely and rapidly increased by the very high temperature to which the gas is raised as the cordite burns This pressure, of course, is what forces the shell out of the muzzle of the gun. Compared with high explosives, cordite is slow burning, and consequently the full extent of the pressure is not exerted in a single fraction of a second The longer, therefore, the shell is under the full effect of the pressure, the greater the force with which it will be expelled by the expanding gas But as soon as the shell leaves the gun, the remaining pressure of the gas, no longer confined, is expended on the surrounding air in all directions, and no longer affects the shell The longer, therefore, the barrel of the gun, the longer is the shell held in contact with the pressure of the expanding gas, and the more forcible will its eventual expulsion be.



HOW A BIG NAVAL GUN IS FIRED

**Fig. 11.** (A) *Section of loaded gun 1, Electric firing tube in position in breech 2, Insulated wire lead to firing pistol 3, Breech block 4, Cordite in silken bag 5, Priming charge 6, Driving band of shell made of soft copper 7, Shell 8, Gun barrel 9, Rifling.* (B) *Section of electric firing tube 1, Stud in contact with insulated wire to firing pistol 2, Centre tube, up which current passes 3, Fine wire bridge which glows white hot, igniting powder around it 4, Vulcanite insulator 5, Easily ignited powder surrounding fine wire bridge. 6, Perforated paper disc 7, Gunpowder 8, Paper end-plug* (C) *Section of high-explosive shell 1, Impact fuse (see* D) *screwed into nose of shell 2, Priming composition 3, Lyddite (high explosive) 4, Soft copper driving band* (D) *Section of impact fuse 1, Small steel block 2, Soft wire safety mechanism 3, Striker 4, Detonator 5, Flash powder filling 6, Flash holes*

Not only does the cordite exert an enormous strain on the gun barrel, but this strain is greatest at the breech, for by the time the gas reaches the nose of the gun, much expansion has already occurred and the pressure on any single part of the interior of the gun barrel is correspondingly lessened For this reason a gun barrel is made thickest near the breech In early models of heavy guns the barrels were made in one piece, their rigid strength alone withstanding the pressure. The introduction of the wire-wound gun gave a degree of elasticity

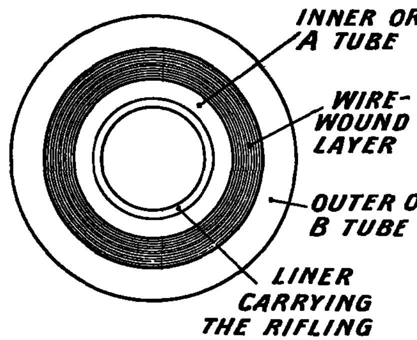
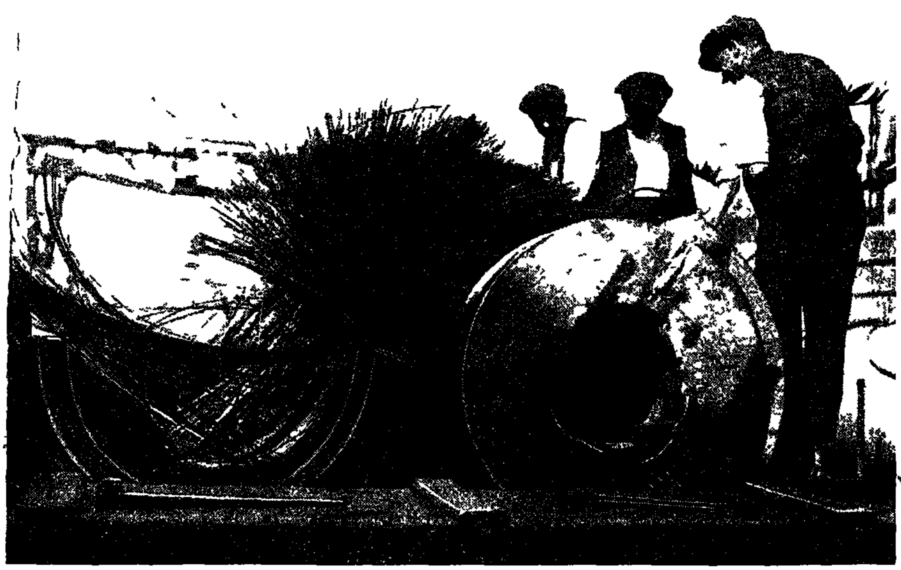



**Fig. 12.** *Section of gun barrel, showing the four layers of which it is composed.*



MILES AND MILES OF WIRE

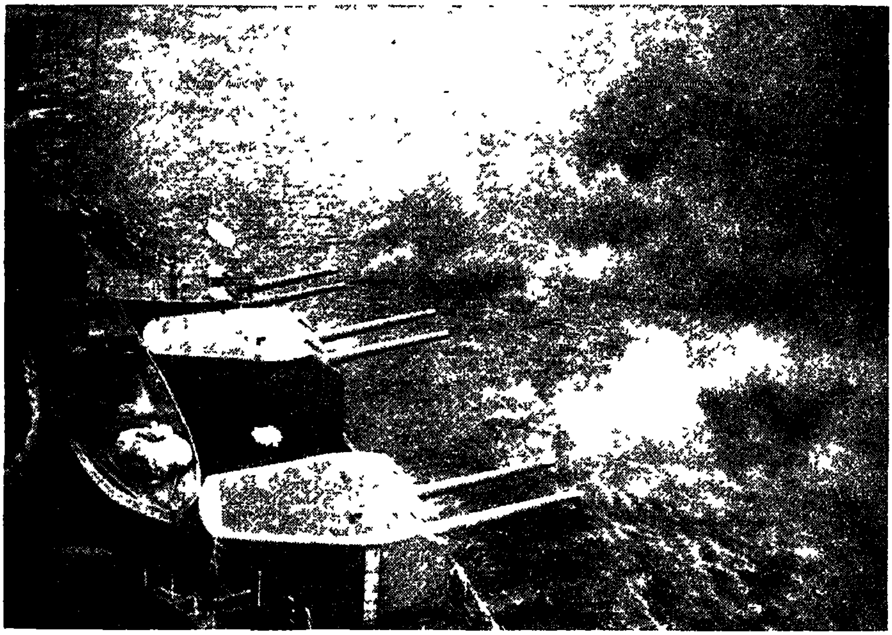
**Fig. 13.** *An idea of the vast quantity of wire, often amounting to over 100 miles, formerly used in the making of a gun The illustration shows obsolete guns being broken up*

which took up much of the pressure.

In the wire-wound gun there are four layers (Fig. 12) The inmost layer, or liner, carries the rifling. This causes the shell to spin, for reasons that we shall see later. Naturally, this rifling is subjected to very heavy wear, and it is therefore so arranged that it can be replaced when it is no longer serviceable. The liner is forced by hydraulic means into the next tube, the A tube, on the outside of which is wound a quantity of steel wire In the making of a large gun, hundreds of miles of this wire are used, and it is wound on more thickly at the breech end of the gun barrel. An idea of the amount of wire used can be gained from Fig. 13. Outside the wire is the B tube, the inside diameter of which is slightly smaller than the outside diameter of the layer of wire. Since metals expand when heated, the B tube can be made to pass over the wire winding by heating it until its inside diameter has sufficiently increased When the outer tube cools, it shrinks and holds the wire tightly in position In later guns strip steel, slightly over $\frac{1}{24}$ inch in width, was used for the winding in place of wire. In the very latest types of big guns, both wire and strip steel are dispensed with, their place being taken by a number of steel tubes shrunk on to one another Besides the important fact that this latest method is less costly, it has the advantage that there is less tendency for the barrel to "whip," and so spoil the aim, as the shell is discharged.

**PURPOSE OF "RIFLING"**

We have already referred to the "rifling" of the inside of the gun barrel. The purpose of this is to make the shell spin—to give it a gyroscopic action that keeps it travelling nose first. Without this spinning action the shell



H M S "RODNEY'S" SECONDARY ARMAMENT

*H M S "Rodney," sister ship of the "Nelson," carries as part of her secondary armament twelve 6-inch guns mounted in six twin-gun turrets, three port and three starboard, in the stern The six port guns are seen firing a broadside in this picture Notice the way the blast has rippled the water The blast from larger guns can cause great damage*

would turn over and over as it flew through the air Each shell is surrounded by a copper band, a little larger than the bore of the gun barrel (*see* A6, Fig 11) As the shell is propelled along the barrel, this copper band is forced into the grooves of the rifling, and, being comparatively soft, it "gives," causing the shell to turn in the rifling as a bolt does in a nut with a gently spiralling thread

### PROBLEM OF RECOIL

The speed at which a shell leaves a big gun is something like 2,000 miles per hour Starting off so great a weight at such a speed creates a tremendous backward pressure, or recoil. If the gun were built rigid on its mounting, the absorption of this recoil would result in damage, it is therefore necessary to provide some means for the barrel of the gun to move backwards in absorbing the recoil

The problem is solved in big naval guns by the use of a hydraulic recoil absorber This works on much the same principle as the hydraulic shock absorbers on motor car springs Attached to the barrel of the gun is a piston with certain small openings. This works in a cylinder of oil fixed to the cradle of the gun The gun barrel is able to slide along the cradle, and when the gun is fired it attempts to move quickly backwards, but the piston in the cylinder of oil prevents it doing so. The pressure forces the oil slowly through the openings in the piston, and thus the recoil is absorbed Though a big gun weighs something like 100 tons, its recoil movement is arrested by this device in about three feet By storing some of the recoil pressure in springs or compressed air, power

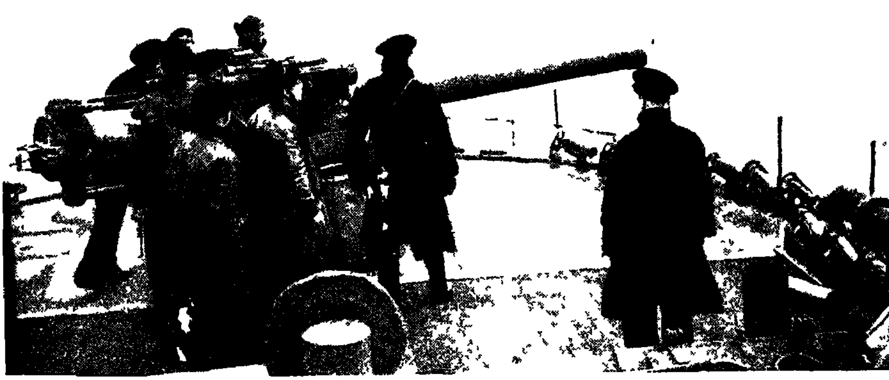
RECOIL OF A NAVAL GUN

*Big naval guns recoil three feet or more when fired. In this picture the camera has caught the beginning of recoil. The nearer gun is perceptibly shorter than its fellow*

is provided to return the gun to its normal firing position.

Of medium guns a number of varying sizes are in use in the British Navy, ranging up to the 8-inch guns of the larger cruisers. All these types are breech loading, but not all are turret guns, and their ammunition arrangements often differ from the heavy guns.

The largest medium gun, the 8-inch, follows the same principles in design and operation as the heavy guns already described. Shells for these guns weigh a little over 2 cwt., and they leave the muzzles at the highest speed attained in naval gunnery. The next size, the 6-inch gun, is used for the main armament of the majority of cruisers and for the secondary armament of battleships and battle cruisers. It is usually employed as a turret gun and is loaded by hand. A few 5.5-inch guns are in use, but the new 5.25-inch gun comes next in importance. Below this ranks the 4.7-inch gun



DEFENDING MERCHANT SHIPS AGAINST U-BOATS

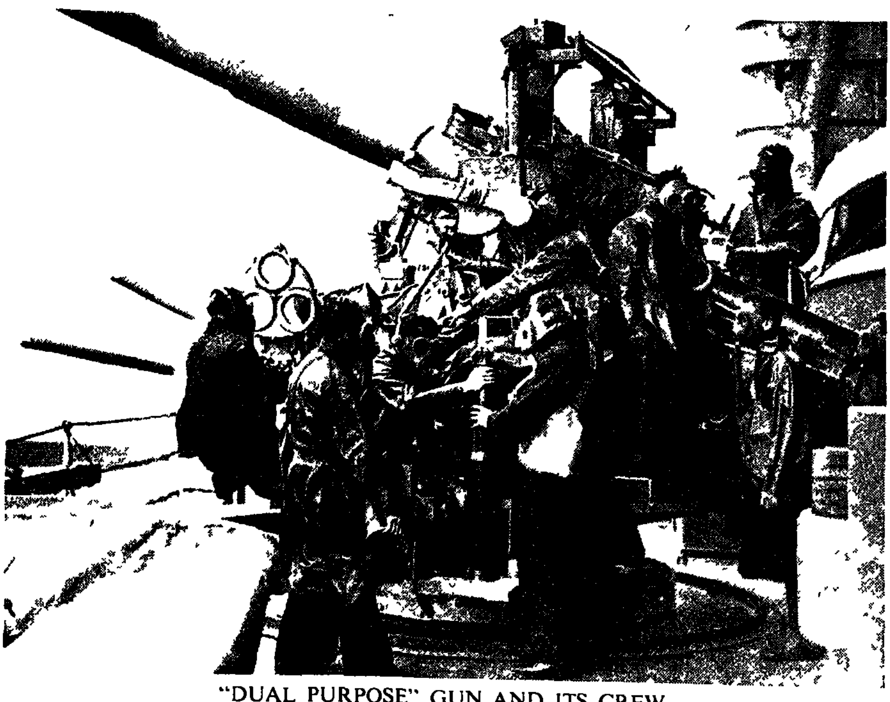
**Fig. 14.** *Smaller guns are not mounted in turrets, but are operated by hand. Guns like the 4.7-inch illustrated above are mounted on merchant ships in wartime*

(Fig. 14). It is also worked by hand, and is employed in most of the destroyers of the British Navy.

These medium guns use shells fired by separate charges, but in some instances the charges are carried in brass cases. The light guns, however, use what is called "fixed ammunition" That is to say, the charge and shell are assembled before loading, and are fed into the breech just like a rifle cartridge.

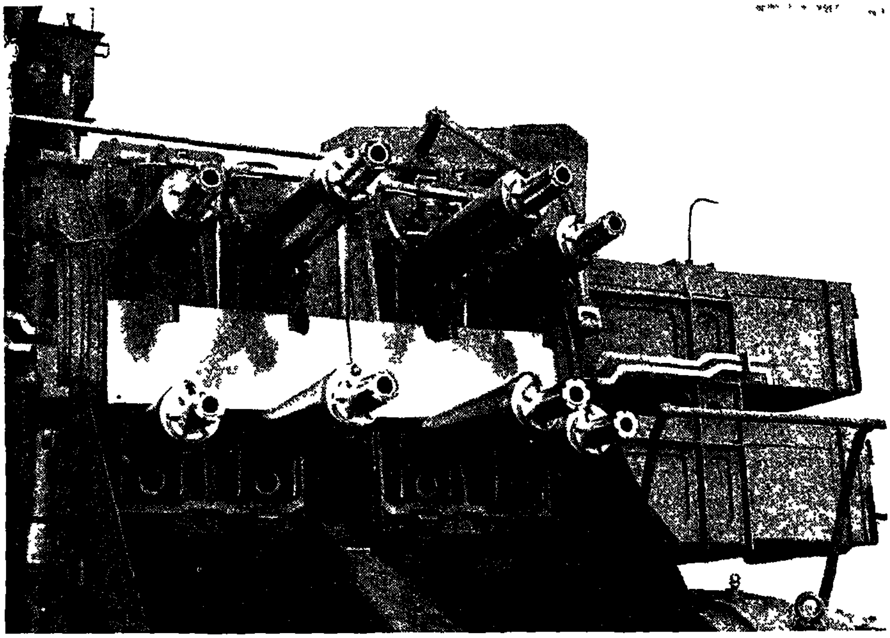
### "DUAL PURPOSE" GUN

Although anti-aircraft guns might be placed in a class by themselves, the largest of them are equal in bore to the smallest of the "medium guns" As we shall see in a moment, some of them are not restricted to the kind of work their name suggest. The biggest, of 4.7-inch calibre, fires a shell that is slightly lighter than that of the guns of the sam size used on destroyers. Next comes the 4 5-inch "dual-purpose" anti-aircraf gun (Fig. 15), the gunnery experts solution of one of the most pressing problems of modern naval warfare, that is, how to keep pace with the rapid developments in aircraft, and the consequent increased danger of air attack on ships that must carry ever more anti-aircraft guns to cope with the menace from the skies, and, at the same time, to prevent the extra weight of these additional guns from causing too big a sacrifice of armament suitable for use against enemy surface craft. The 4 5-inch gun has the elevation and rate of fire necessary for dealing with aircraft, but may also be lowered to provide an



"DUAL PURPOSE" GUN AND ITS CREW

**Fig. 15.** *The 4 5-inch "dual purpose" anti-aircraft gun was designed to save warships from the necessity of carrying extra guns. It has the elevation and rate of fire needed to deal with aircraft and can also be used against surface ships or submarines*



ARMAMENT THAT THE DIVE BOMBER FEARS—THE 'POM-POM'

**Fig. 16.** *This eight-gun pom-pom puts up a barrage of 2-lb. explosive shells in the path of approaching enemy aircraft at an amazing rate. Water cooled, and manned by a crew of six or more men, this formidable weapon is extensively mounted on British ships*

effective weapon against enemy ships. These guns, which are mounted in pairs in twin mounts, are the ideal weapons for aircraft carriers, which, though not designed to engage other vessels, may occasionally be forced by circumstances to do so. Guns of this type are mounted in H.M.S. *Ark Royal*, though in earlier aircraft carriers anti-aircraft guns of 4-inch calibre are also in use.

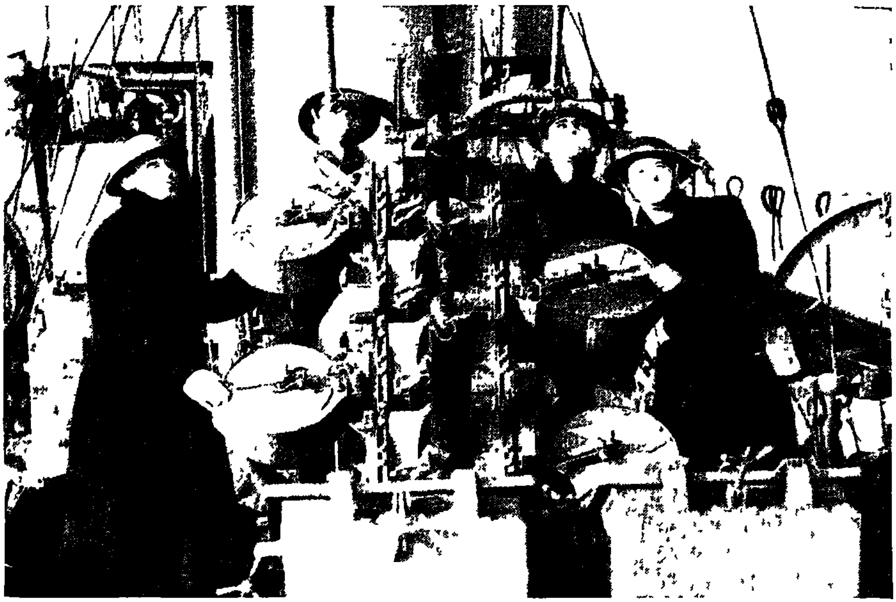
Dual-purpose guns are intended mainly to deal with high-flying aircraft. Aerial attacks on ships, however, as we shall see later in the chapter on the Fleet Air Arm, often involve low-flying aircraft and dive bombing. For protection against attacks of this kind, two special types of gun have been invented.

The first of these, known as the multiple pom-pom (Fig. 16), is really a bank of several guns It is made in two types, one having four barrels, the other eight. The complete nest of guns is mounted on a revolving platform that carries the whole of the gun's crew of six or more men. These guns fire 2-lb. shells at a great rate—the actual rate being secret

### ANTI-AIRCRAFT BARRAGE

The shells are fed into each of the guns on belts, in much the same way as bullets are fed into machine guns. The guns are water-cooled to enable them to stand up to the high rate of fire, the water jackets extending nearly the whole length of the barrels. The 1-inch shells are of explosive type, and the gun is aimed in the path of approaching aircraft on the principle of a scatter-gun, putting up so close a barrage that it is doubtful whether any aircraft caught in it could survive.

The second special type of gun



VICKERS MULTIPLE ANTI-AIRCRAFT GUN READY FOR RAIDERS

**Fig. 17.** *Like the pom-pom, the multiple anti-aircraft gun is really a nest of guns It consists of four machine guns mounted together, each firing bullets ½-inch in diameter*

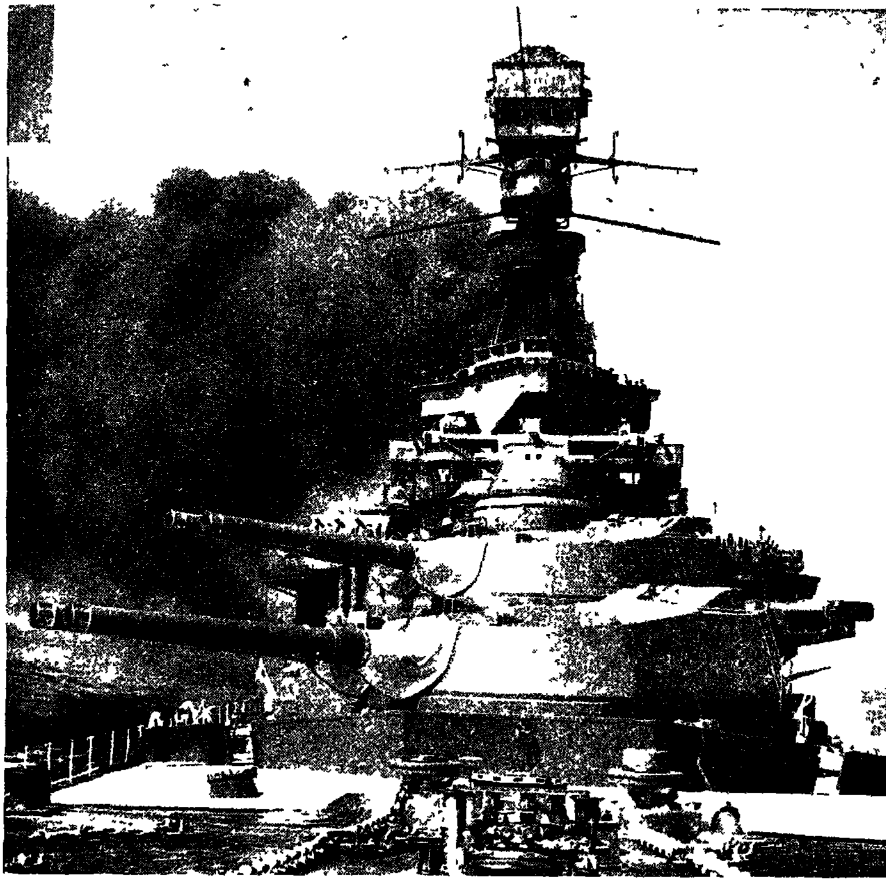
used for encountering attacks by low-flying aircraft is also, in effect, a nest of guns. It consists of a set of four ordinary machine guns (Fig. 17), mounted together, and firing bullets of ½-inch diameter, larger than machine gun bullets

### OPERATION OF GUNS

Now that we know something of the main types of gun that make up the armament of the modern ship of war, we are ready to consider their operation. Because of the long range over which they have to work, the operation of turret guns is a complicated business, and many factors have to be taken into consideration For instance, when firing heavy guns at maximum range, allowance must even be made for the effect of the earth's rotation on the shells The time taken by a shell to reach its target may be a few seconds, and during this time the earth—due to its rotation—will have moved beneath the travelling shell The duration of flight and the direction of the shell require allowances to be made for this movement of the earth in long-range firing

Firing a gun involves range finding and gun laying The gun crews do not operate their own guns independently, the work being done for all the guns from a central fire-control position high up in the ship, where visibility is likely to be best from all aspects.

How the guns are laid and fired is explained in Fig. 18 on pages 262 and 263 When the captain of the warship (1) sights his target, he informs the central officer in the control tower (2) who gives its position to the transmitting room (3) The transmitting room warns the turret (4) where the mean range is discovered and sent back to the transmitting room (5) The training of the guns is then reported from the transmitting room to



CONTROL TOWER AND RANGE FINDER OF A WARSHIP

*The fire of a warship's main guns is directed from a central fire-control point at the top of the control tower Here gunnery officers work out the elevation and direction for the big guns and from here the guns are actually fired This picture shows clearly the range finder directly above the two-gun turret, and the control tower in the superstructure.*

the gunlayer, and the order "load guns" sent from the control tower (6) through the transmitting room to the turret (7). The "guns ready" signal is sent back to the transmitting room (8) and the "fire" signal goes from the transmitting room (9) to the trainer in the control tower, who pulls the trigger (10).

This complicated system is applied to every gun turret in the ship, and, during an action the transmitting room is a hive of activity. Most vessels have a secondary fire-control station that may be used if the main control is damaged.

The distance of the target is calculated by means of the range finder, a complicated optical system of prisms and lenses in which two images of the distant warship are seen by the operator. After adjusting the instrument so that these two images bear a certain relation to each other—a relation that varies according to the type of range finder used—the operator can read off the range on an

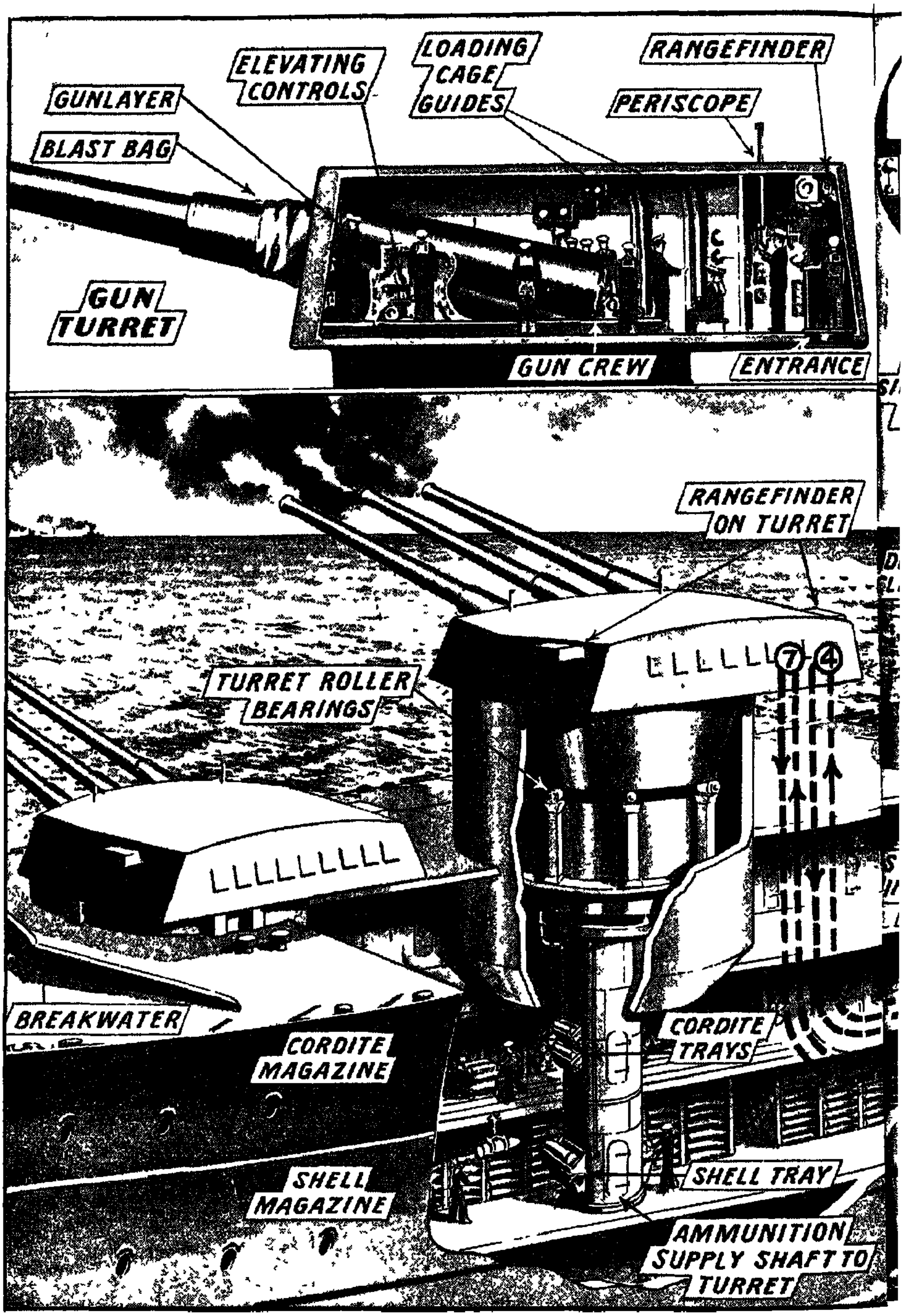
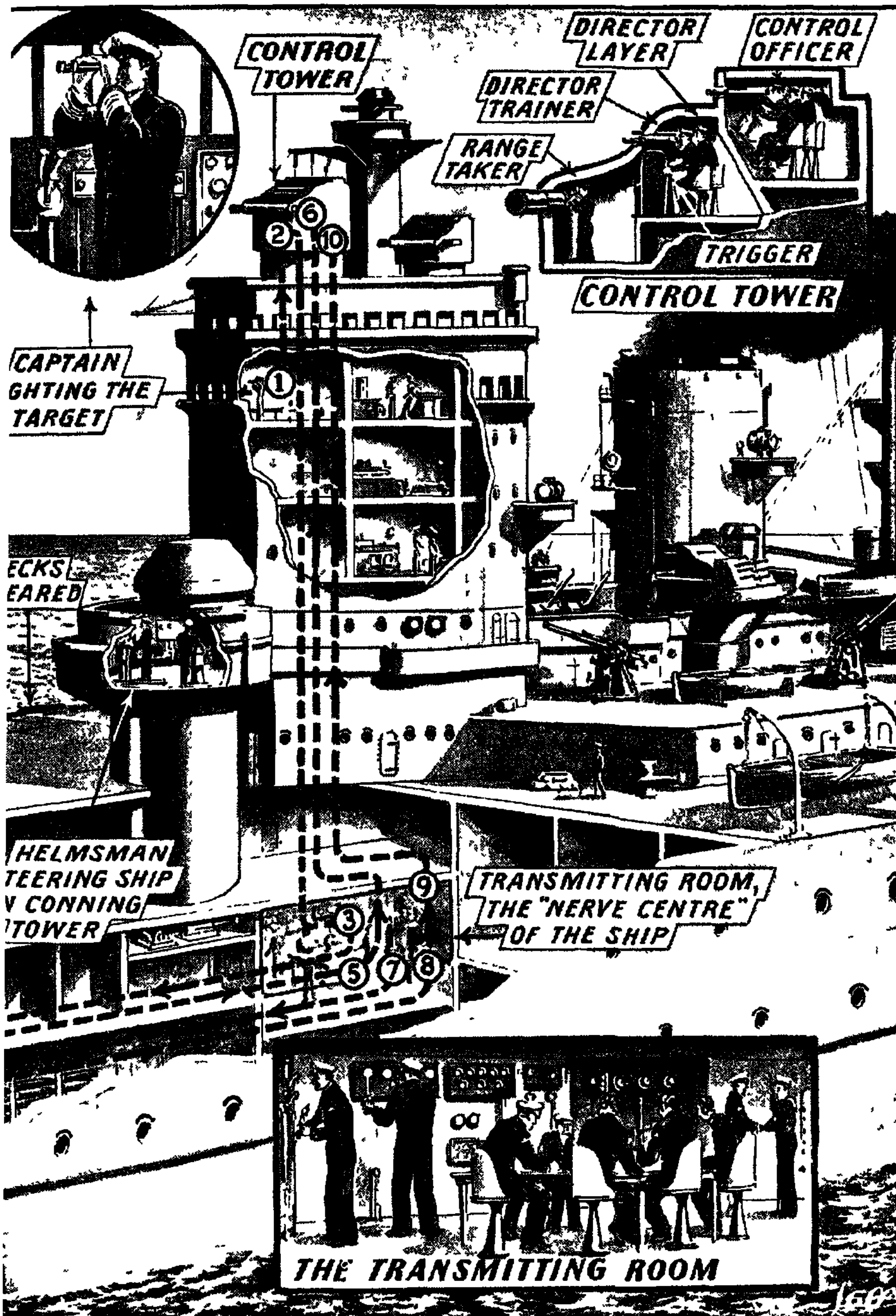



Fig. 18. *How the guns of a battleship are aimed and fired from a central control tower*




*High up in the superstructure (For explanation and key to the numbers, see page 260.)*

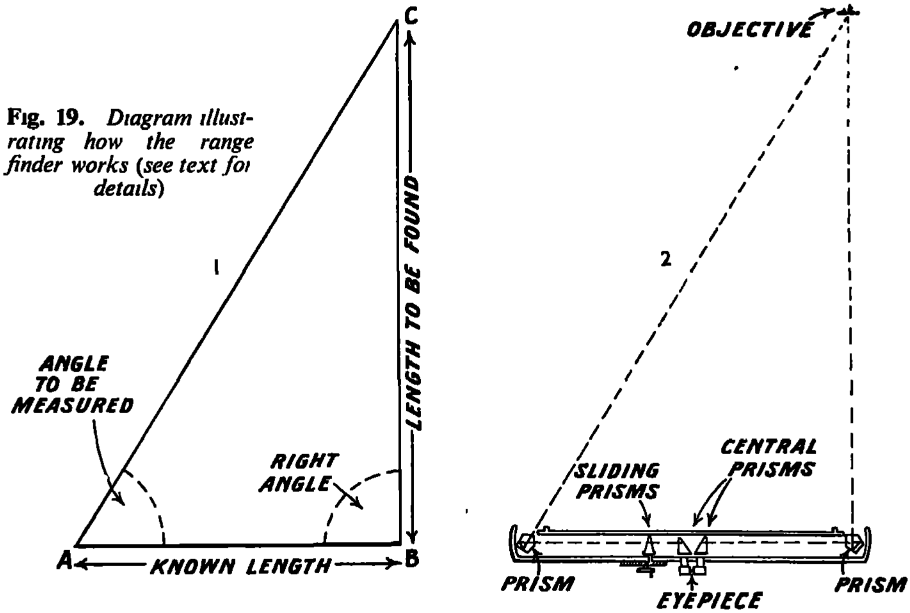



**Fig. 19.** *Diagram illustrating how the range finder works (see text for details)*

indicator connected to the instrument. The general principle of all range finders is similar, but a considerable number of types are in use

The theory on the basis of which the range is worked out is illustrated at 1 in Fig 19, while at 2 we can see how the triangle concerned is related to the range finder and to the enemy warship. If the length of the base of a triangle is known, and the angles that the other two sides of the triangle make with its base are also known, it is a simple matter to calculate the lengths of the other two sides Referring to the figure, we can easily see that the operator knows the length AB of the base of the triangle ABC, because it is the length of the range finder itself. He also knows the angle at B, for it is always set to an angle of ninety degrees When the range finder is set so that the two lines of sight, BC and AC, meet at the enemy warship, the angle at A—or, alternatively, the length of BC—can be read off

One of the duties of the fire-control officer, high up in the superstructure of the warship, is to ensure that the range finder and the guns are operating on the same target. This may sound a little surprising, but we must remember that a ship does not look very large at a distance of ten miles and that there may be a number of enemy warships in view in the same direction. For the same reason he must be careful not to confuse the return fire from the ship that is his objective with that from any other ship that may be simultaneously directing her fire at his own ship. Even at the high speed with which they are discharged, shells take a few seconds to travel ten miles Nowadays, the fire-control officer may receive help in these matters, as we shall see in a later chapter, by reports wirelessed from the ship's aircraft that are observing the fall of the shells in relation to the target.

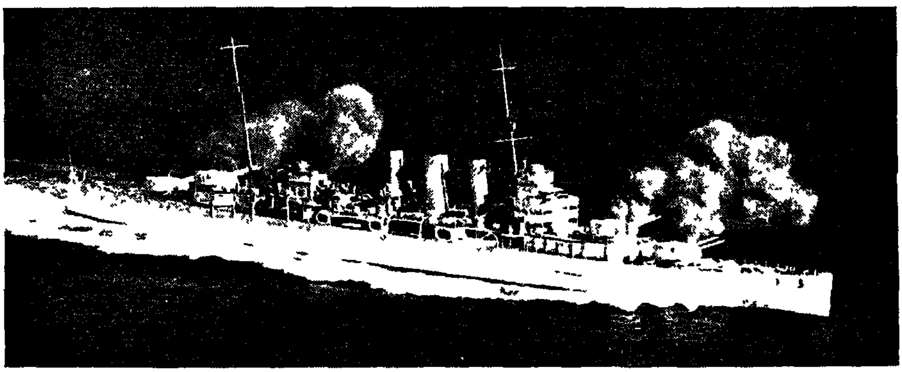
In working out the elevation and direction for the guns, the officer must take into account the speed and course both of his own ship and of the ship that is the object of the fire As courses alter

and distances are continually changing during an engagement, new details must continually be worked out, and each new instruction for gun laying must take into account such varying factors as wind direction and weather conditions. The range-finder readings and observations taken by the control officer may be transmitted directly by mechanical means to the transmitting station, a well-protected office low down in the vessel (Fig. 18) where all the necessary calculations are made. This office will be supplied with large chart tables with elaborate slide-rule devices to enable the required details to be arrived at quickly, and with indicators to show the state of readiness of each gun in the various gun turrets

The control officer operates a master director, which he constantly resets in accordance with the information sent up to him from the plotting room below. As he makes adjustments and trains his sights (exactly as one would train a small gun) the gun laying details are transmitted automatically to each gun turret. The guns all follow the master director, so that when the control officer has his sights on the target he is able to fire the prearranged number of guns simultaneously by pulling the trigger. Immediately the guns are fired, an indicator will tell him how long his shells will take to reach the target, and he is able to watch for their effect.

In spite of the range finders and the calculations made in the plotting room, the shells may be seen to fall short of or beyond the target The control officer will then give instructions to the plotting personnel to modify the range in the direction required If, on the other hand, shells are seen to fall on the target, rapid fire may be started The guns are usually fired in salvos, a salvo consisting of half the main guns of the ship; thus, if the guns are mounted in the turrets in pairs, the right-hand guns may all be fired first, then all the left-hand guns, one set being reloaded while the others are firing. A broadside, when all the guns fire at once, is only likely to be employed at short range.

Obviously, if a ship is rolling badly, the fire may be thrown completely off the target. To overcome this difficulty, a gyroscopic device is in use to prevent the guns from firing except at one point in a roll, even though the control officer should pull the trigger of his



H M S "DEVONSHIRE" FIRES A SALVO

*A salvo consists of half of the ship's armament fired simultaneously In the case of ships mounting their guns in two-gun turrets, as in this picture of a salvo from the cruiser "Devonshire," only one of each pair of guns is fired at the same time*

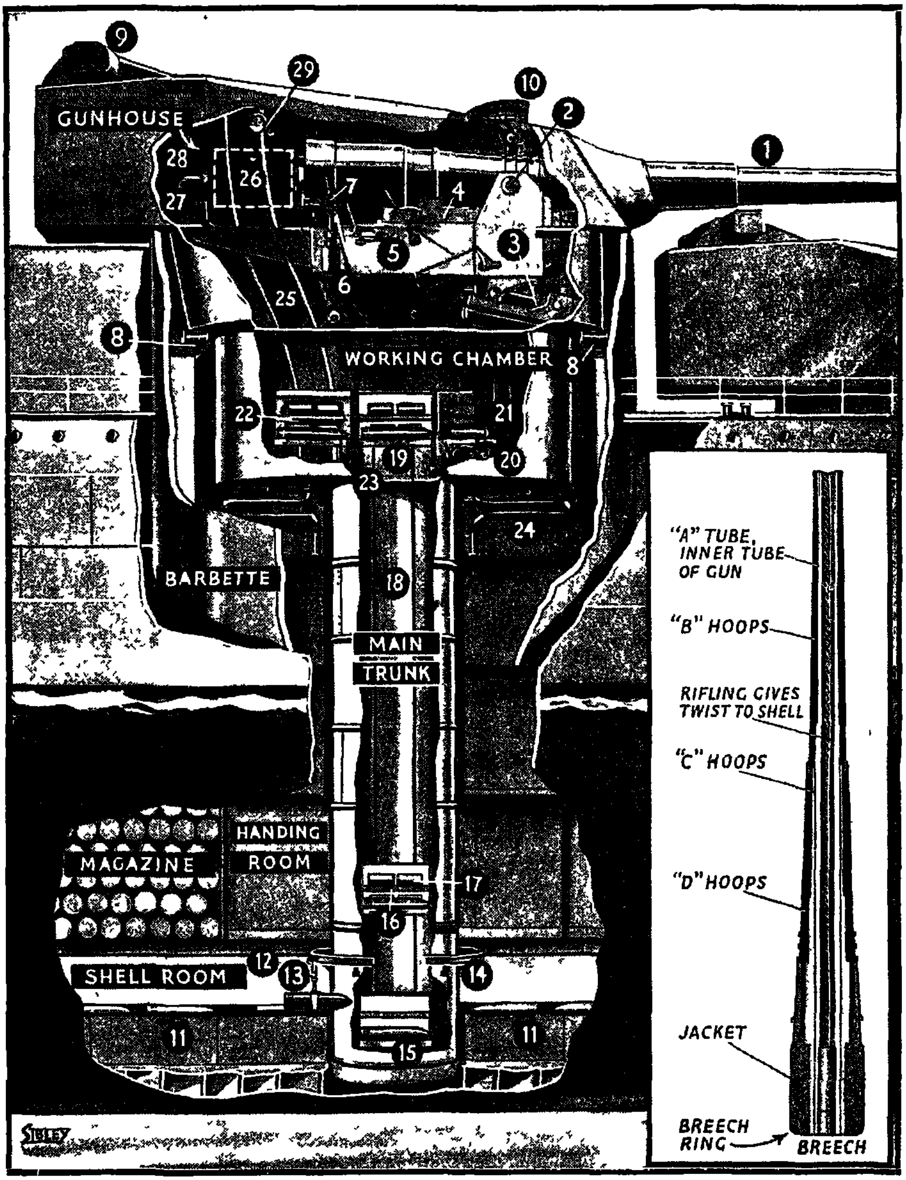
BROADSIDE FROM THE BATTLE CRUISER "RENOWN"

*All the main guns of a ship firing together constitutes a broadside Broadsides are only delivered when it is practically certain that the shells will reach their target This picture gives a fine impression of H M S "Renown's" broadside, and even the warship's list, which is actually a recoil from the firing, can be detected*

director before that stage in the roll is reached This arrangement cancels out the effects of the rolling. If shells are seen to be falling short because of rolling, alterations in range can be made with confidence, in the knowledge that the ship will be in the same stage of a roll when the guns next fire.

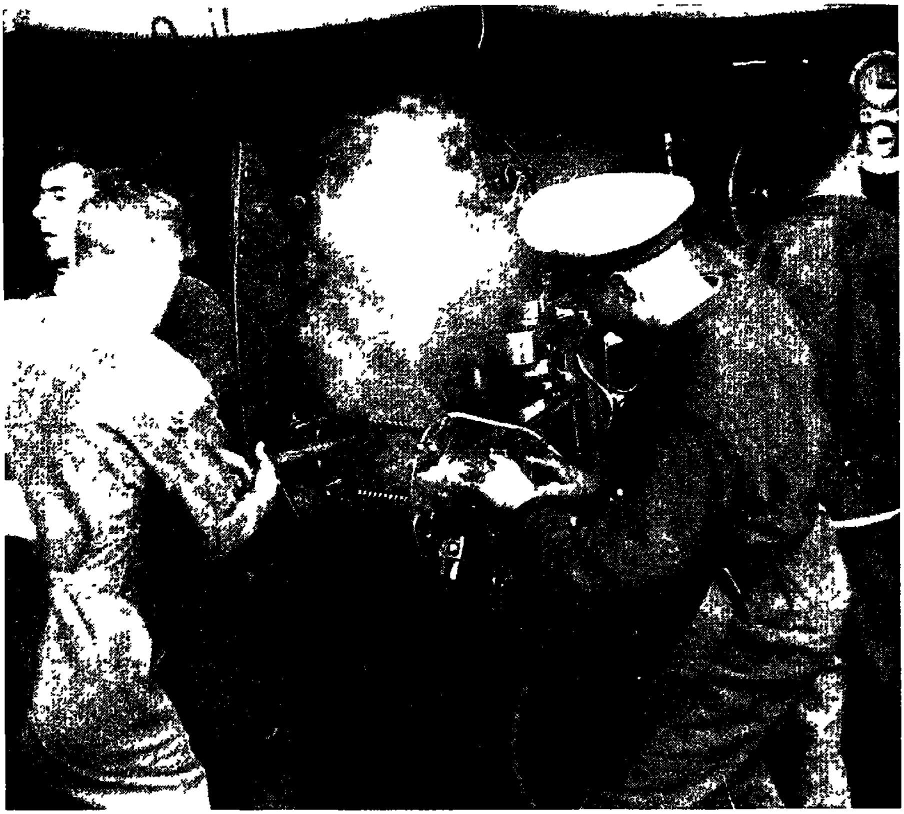
Now let us go along to one of the gun turrets where the men, who are playing so big a part in the operations of a battle, know next to nothing of how it is progressing Behind the thick armour, each member of the gun crew has his appointed task to carry out, and he must perform it efficiently at exactly the correct moment in the sequence of operations. First the shell comes from below, carried mechanically through the loading tube to the open breech of the gun, and mechanically rammed home (Fig. 20). Meanwhile, a new firing tube is being inserted into the breech block The charge follows the shell into the breech, is rammed home, and the breech closed. By this time the gun has been laid, and the "all ready" signal sent to the plotting room and the control officer. Before the gun is fired from the control bridge, a gong sounds in the turret to warn the members of its crew.

The report of a big naval gun is terrific, and when a salvo or broadside of guns is fired by a battleship the noise




MECHANICS OF A 15-INCH GUN TURRET

**Fig. 20.** *1, Two 15-inch guns 2, Trunnion 3, Elevating gear. 4, Cradle 5, Slide 6 and 7, Breech opening motor and gear 8, Rollers upon which turret revolves 9, Range finder 10, Centre sighting hood 11, Shell bins 12, Overhead tracking for moving shells 13, Shell lifting and lowering gear 14, Circular trackway 15, Shell in tray 16, Cordite trays 17, Cordite charges 18, Cables 19, Ammunition cage 20, Cage hoist 21, Cordite and shell rammers for loading 22, Gun cage. 23, Gun-loading cage hoist 24, Hydraulic power pipes 25, Cage guide rails 26, Cage in loading position 27, Rammer 28, Controls 29, Cage hoisting gear (Inset) Section through gun showing tubes and hoops*



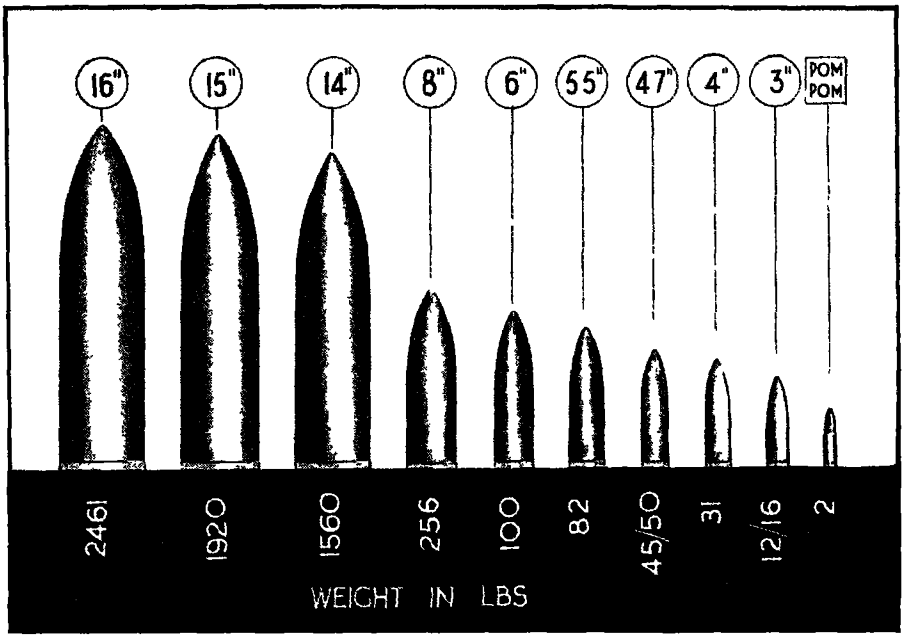
WHEN A NAVAL GUN IS FIRED

*This picture, taken inside one of the 13 5-inch gun turrets of H M S "Iron Duke," shows the gun crew at their stations The gun has just been fired, the breech block is swung back and while the master gunner (in white cap) is fitting a new firing charge the breech is sponged out and prepared to receive the next shell*

is indescribable Because of this, most sailors, in any exposed part of the ship at any rate, wear ear plugs If it is necessary for them to be in constant communication with their officers, they wear a telephone receiver with a tight-fitting pad that cuts out something of the noise Actually, however, the men in a large gun turret hear the sound of the firing of their own guns only as muffled roars.

This is partly because they are protected by the enormously thick armour plating of the turret itself and partly because they are some forty feet away—the length of the gun barrel—from the point where the explosion reaches the air.

None the less, theirs is not an easy job. The explosion of the gun shakes the whole ship and as the barrel recoils, heavy air pressures are set up inside the turret. Immediately the recoil is over, the breech is swung open again and wisps of acrid smoke from the gun barrel begin to filter into the turret. The men always work in electric light, and as this smoke increases—which it does every time the gun is fired—the gloom becomes heavy and the heat terrific. Moreover, the noise made by the




*Comparative weights and sizes of British naval shells*

machinery operating the gun, and the rammer, is never ending—and it is anything but a gentle noise!

Indeed, conditions in one of the many gun turrets of a battleship, which is fighting a long-drawn-out action and is constantly firing its guns, may well become almost unendurable. Yet whatever the sailor feels, he must carry on with his duties and must never allow his attention to wander, or make a mistake in manipulating the delicate machinery under his care.

The type of shell that is being used will vary with the type of gun and the purpose for which it is being fired

Most important among projectiles used for big guns are armour-piercing shells. These, unlike high-explosive shells, do not explode immediately the nose strikes. The explosion, which is fuse controlled, is delayed for the fraction of time necessary for the shells to pierce the armour plate. Owing to the very thick and heavy cases of these shells, they can carry less explosive material than high-explosive shells, and their explosion, in consequence, is less violent.

Some armour-piercing shells have a double cap on the nose (Fig 21). The outer cap, though hard enough to pierce armour plate, is not so hard as the inner. It acts as a kind of shock absorber, spreading a little on reaching its objective The inner cap is thus prevented from fracture, and pushes the first out of the way so that the shell may continue to make its way through the armour (Fig. 21) until it finally explodes.

### ANTI-AIRCRAFT SHELLS

High-explosive shells depend for their effect on the force of the explosion, though the flying fragments of the cases also do much incidental damage Some shells, such as shrapnel and anti-aircraft shells, explode without coming into contact with any object. Shrapnel shells, which are loaded with bullets that are

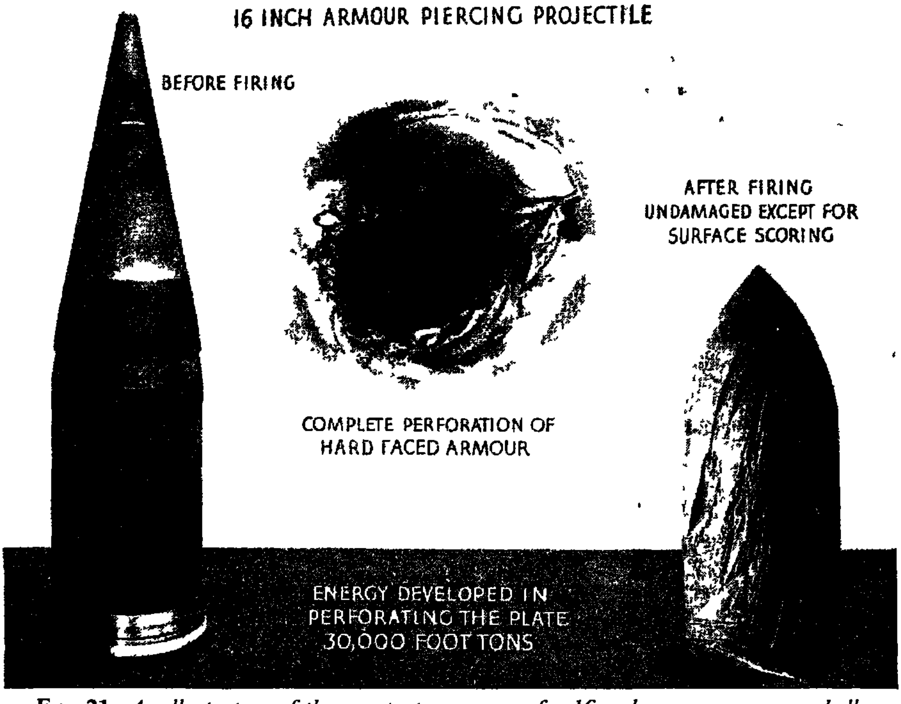



**Fig. 21.** *An illustration of the penetrating power of a 16-inch armour-piercing shell*

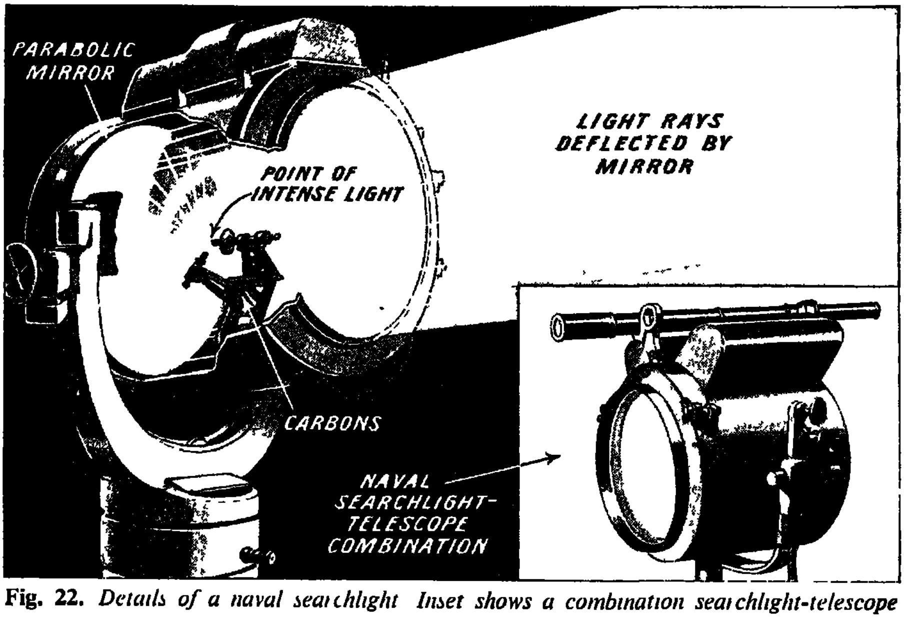


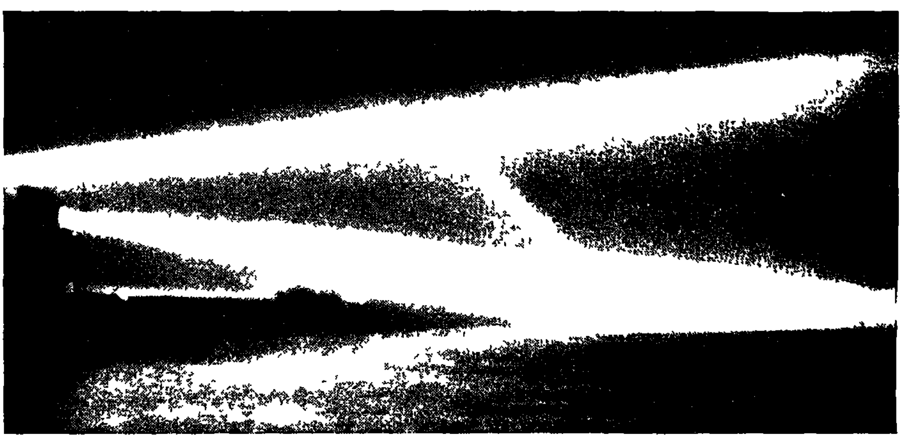

**Fig. 22.** *Details of a naval searchlight Inset shows a combination searchlight-telescope*

dispersed by the force of the explosion, are used against enemy personnel. Anti-aircraft shells are fused to explode as required, for there is small chance of a direct hit when firing at fast-moving aircraft. Explosive shells of these types are operated by a fuse burning inside the shells and actuated by the discharge from the guns. A simple device governs the length of time for which the fuse burns before exploding the shell, and this interval can be adjusted in accordance with the distance of the objective. A safety device is incorporated to obviate the danger of the shells exploding whilst being handled or before they are discharged from the gun.

There is small likelihood of big naval actions taking place under cover of night, for darkness not only makes accurate gunfire difficult, but reduces the chance of opposing fleets spotting each other. But if an engagement does chance to occur in the dark, the gunners are aided by powerful searchlights (Fig 22). Searchlights, indeed, were originally designed for naval use, though their most obvious use today is for spotting enemy aircraft In conditions of clear visibility their powerful beams, of some millions of candle-power, will illuminate a ship many miles away. At sea, as on land, they are also used against enemy aircraft, though it is unlikely that they would be switched on before an aerial attack began, as their beams would disclose to the enemy forces the position of the vessel using them

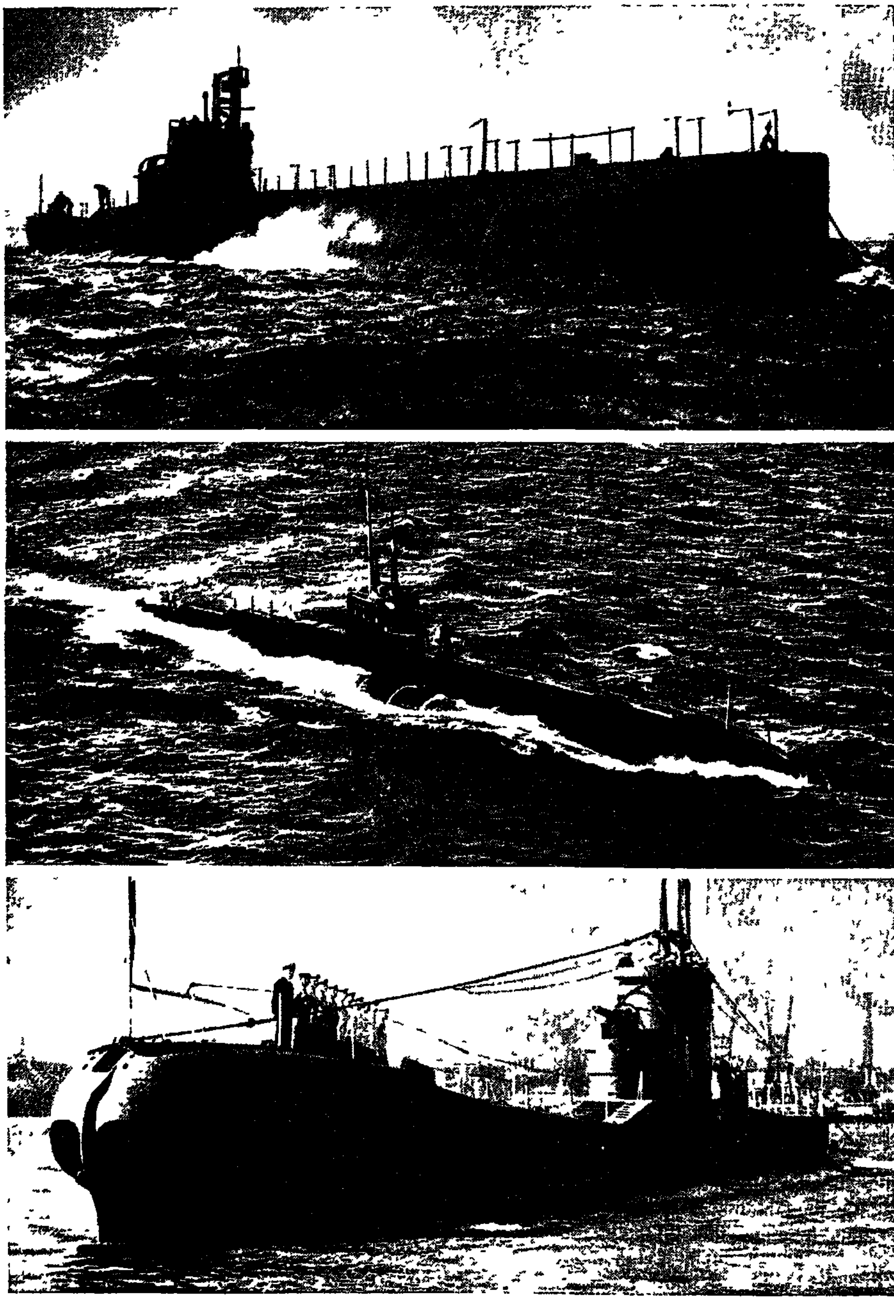
### FOCUSING A SEARCHLIGHT

Since the rays of light from a searchlight are almost parallel, the area illuminated by the beam, even at many miles distant, is still comparatively small. In directing a searchlight on an object a few miles away, it has to be remembered that the smallest movement of the source of light will cause the beam to move, comparatively, a considerable distance, and it is therefore no easy matter to keep an objective focused within the beam. Searchlight operation, whether on land or at sea, is a task requiring no mean degree of special skill



NAVAL SEARCHLIGHTS SWEEPING SKY AND SEA

*Although searchlights are today primarily connected with anti-aircraft batteries, they were originally designed for naval use They enable ships to continue an engagement after dark This picture shows searchlights from shore stations seeking out possible German mine-layers—either aircraft or submarine—off the east coast of Britain*



THREE TYPES OF BRITISH SUBMARINE

(*Top*) *H M S "Porpoise," mine-laying submarine* (*Centre*) *H M S "Salmon," sea-going craft of great manœuvrability* (*Below*) *H M S "Triumph," ocean-going patrol vessel.*

# CHAPTER IX

# SUBMARINES AND TORPEDOES

ALTHOUGH stories of submarine attack and epic tales of escape from the underwater menace play so large, perhaps even the largest, part in our ideas of naval warfare today, it is only in comparatively recent years that armed might has grappled with armed might in the depths of the ocean. Not until the early years of the present century did the submarine find a place in the Royal Navy, and its striking power was first demonstrated under war conditions in the conflict of 1914-18. Then its full possibilities as a destroyer of merchant ships and warships came as a rude shock to those who had refused to take the new weapon seriously. During that war, and in the years following, the submarine was rapidly perfected and improved. In the early years of a new weapon, the development of counter measures tends to lag behind that of the weapon itself. Since the German naval authorities had put greater faith in the submarine's possibilities than had those of any other naval power, and little attention had been paid to devising new defensive measures to cope with it, their U-boat campaign in the war of 1914-18 met with considerable success

### ANTI-U-BOAT MEASURES

Effective counter measures, however, were ultimately evolved, and were soon developing at a rate which kept pace with improvements in the submarine itself, and these counter measures have now become so effective that it is highly improbable that the submarine will ever again prove so great a menace as it was in 1917.

The great successes the British and French Navies gained in their campaign against the U-boats in the early stages of the war did much to justify and strengthen this belief.

The submarine has been used by Germany as an instrument of blockade. As such it attacks unarmed merchant ships, and sinks without warning harmless passenger vessels carrying women and children. But this is not its only, or indeed, its proper role in legitimate naval warfare. British submarines, for example, play a most valuable part in the work of the Navy.

### "TAKING COVER" AT SEA

The greatest disadvantage of the surface vessel as a fighting medium is that it cannot take cover the smallest ship is visible at sea for many miles. The submarine's capacity for hiding by submersion is therefore its outstanding advantage, and this advantage is great enough to outweigh the enormous disadvantages of risk and hardship which must be endured to secure it.

The submarine's principal weapon of attack is the torpedo This weapon is not exclusive to the submarine, for it is also employed by destroyers, but in their case it can hardly be considered as their principal weapon. One class of surface vessels—the motor torpedo boat—also uses the torpedo as its principal weapon of attack, and will therefore be considered, with the submarine and the torpedo itself, in this chapter, which will also deal with some of the anti-submarine and anti-torpedo devices in use at the present day.

The submarines used in the Royal Navy (Fig. 1) may be classed in four types, according to the duties they are called upon to perform First, there are

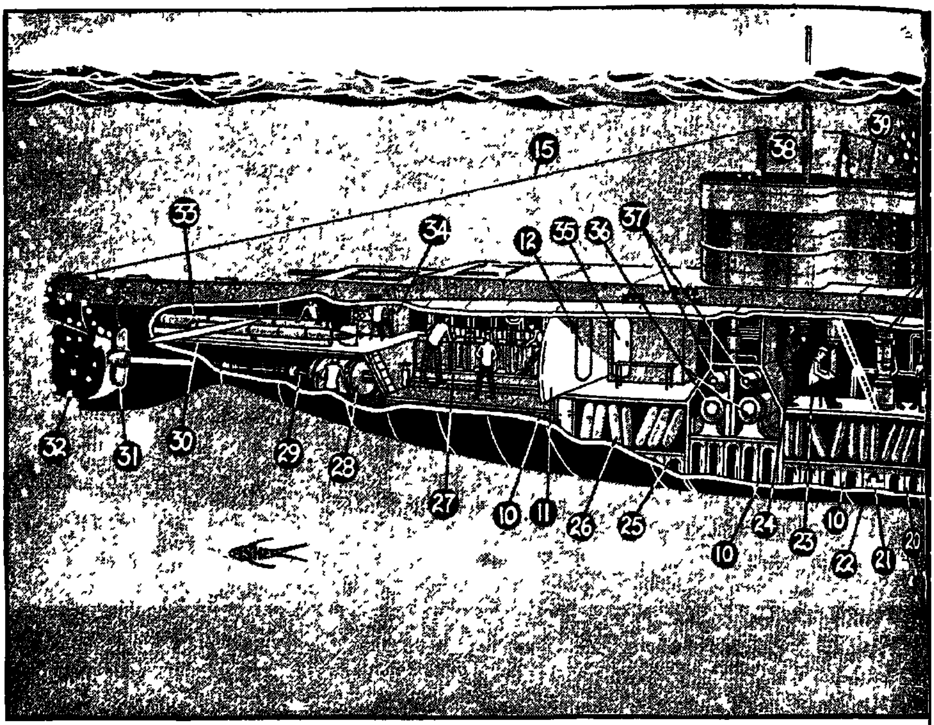
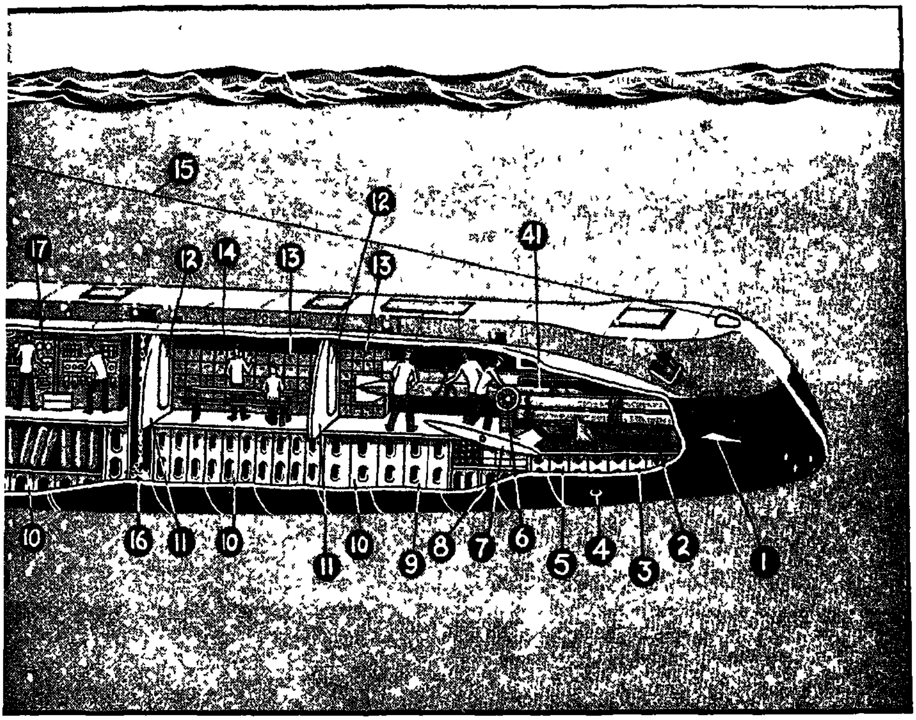



DIAGRAM OF A TYPICAL

**Fig. 1.** *1, Bow torpedo tube doors (starboard) 2, Torpedo tubes 3, Forward trimming tank 4, Hydroplane 5, Compensating tank 6, Wheel controlling torpedo tube doors 7, Forward hydroplane 8, Torpedo tube flooding tank 9, No 1 oil fuel and compensating tank 10, Internal ballast tanks 11, Bulkheads 12, Watertight doors 13, Lockers 14, Officers' mess 15, Jumping wire (to avoid entanglement in nets) 16, Cable locker 17, Main battery switchboard 18, Gear for operating hydroplanes 19, Compressed air bottles 20, Buoyancy*

the ocean-going vessels used for patrol work which have long ranges and can remain at sea for three weeks or more Next come the fleet submarines which work with vessels of other types in a fighting formation. These have a higher speed than the ocean-going submarines, and so are able to keep up with surface craft The submarine, especially when submerged, is not normally a fast craft. Thirdly, there is the mine-laying submarine, used for laying mines in difficult areas—such as near the enemy coast—where surface minelayers cannot work Lastly come the small submarines, frequently known as coastal submarines. used for short range patrol duties. The three types of submarines used in the German Navy are illustrated in Fig. 2

Quite apart from the hazardous nature of the operations which a submarine crew is called upon to undertake, their life on board is anything but pleasant and comfortable. Every possible square inch of space is required for the engines and machinery. Scarcely can room be found for the barest necessities. The officers, for instance, have no proper wardroom, a curtained-off portion of the main fore and aft gangway is all that can be spared (*see* illustration on page 279) Even air must be carefully rationed·

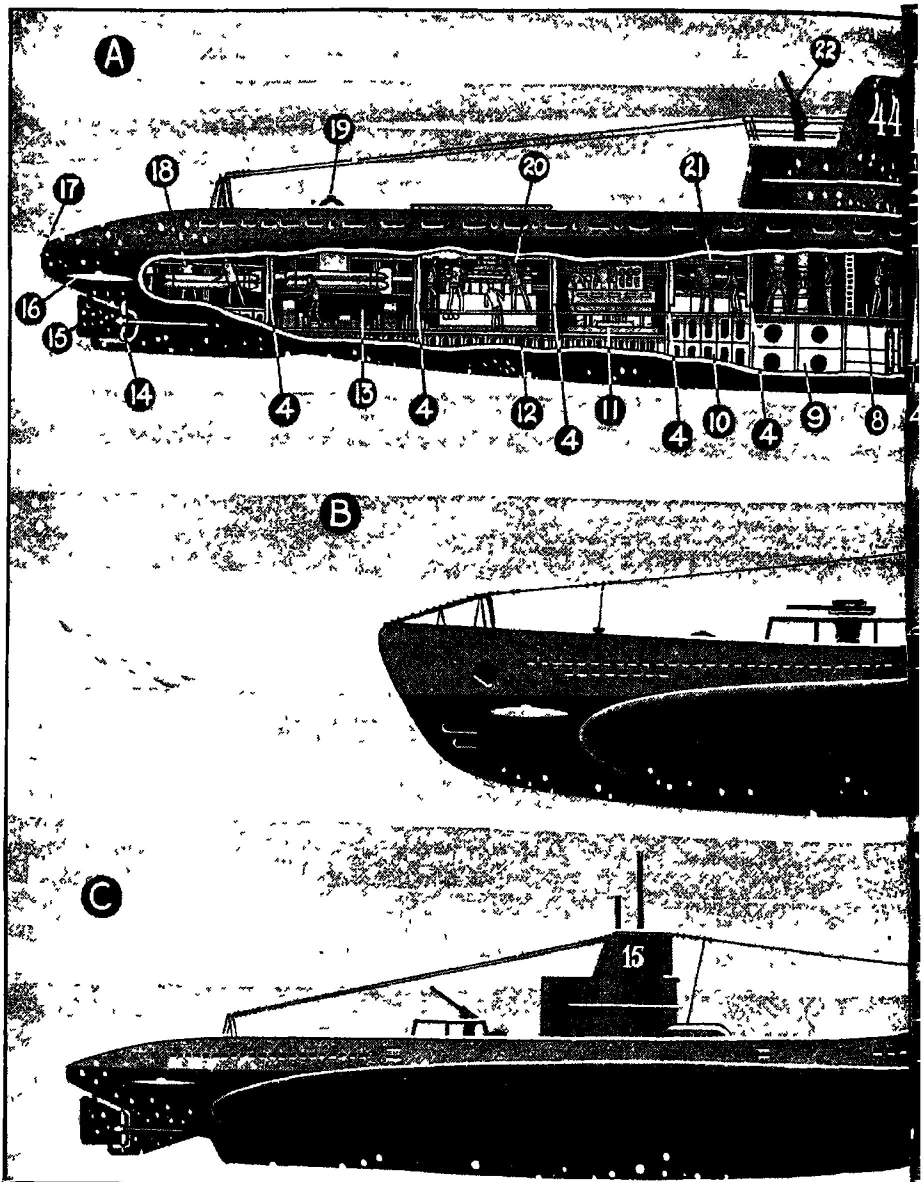



BRITISH SUBMARINE
*tank 21, Dropping gear for detachable keel 22, Detachable iron keel 23, Steersman 24, Captain at periscope 25, No 2 oil fuel and compensating tank 26, Compressed air bottles 27, Diesel motors for surface cruising 28, Main electric motors for submerged cruising 29, Propeller shaft 30, Aft hydroplane 31, Propellers 32, Rudder 33, After torpedo tubes 34, Main motor switchboard 35, Wireless offices 36, Beam torpedo tubes 37, Torpedoes stowed 38, Periscope 39, Conning tower 40, Quick-firing gun 41, Torpedoes*

though there is sufficient to last for any normal period of underwater duty, the atmosphere inside a submarine below the surface quickly becomes foul and oppressive, and men who are not performing any duties lie motionless. Any physical activity will compel them to consume more oxygen, and every possible cubic foot of the life-sustaining gas must be left for those who need it for the essential work of the vessel. The submarine carries compressed air, it is true, but that is kept for other purposes.

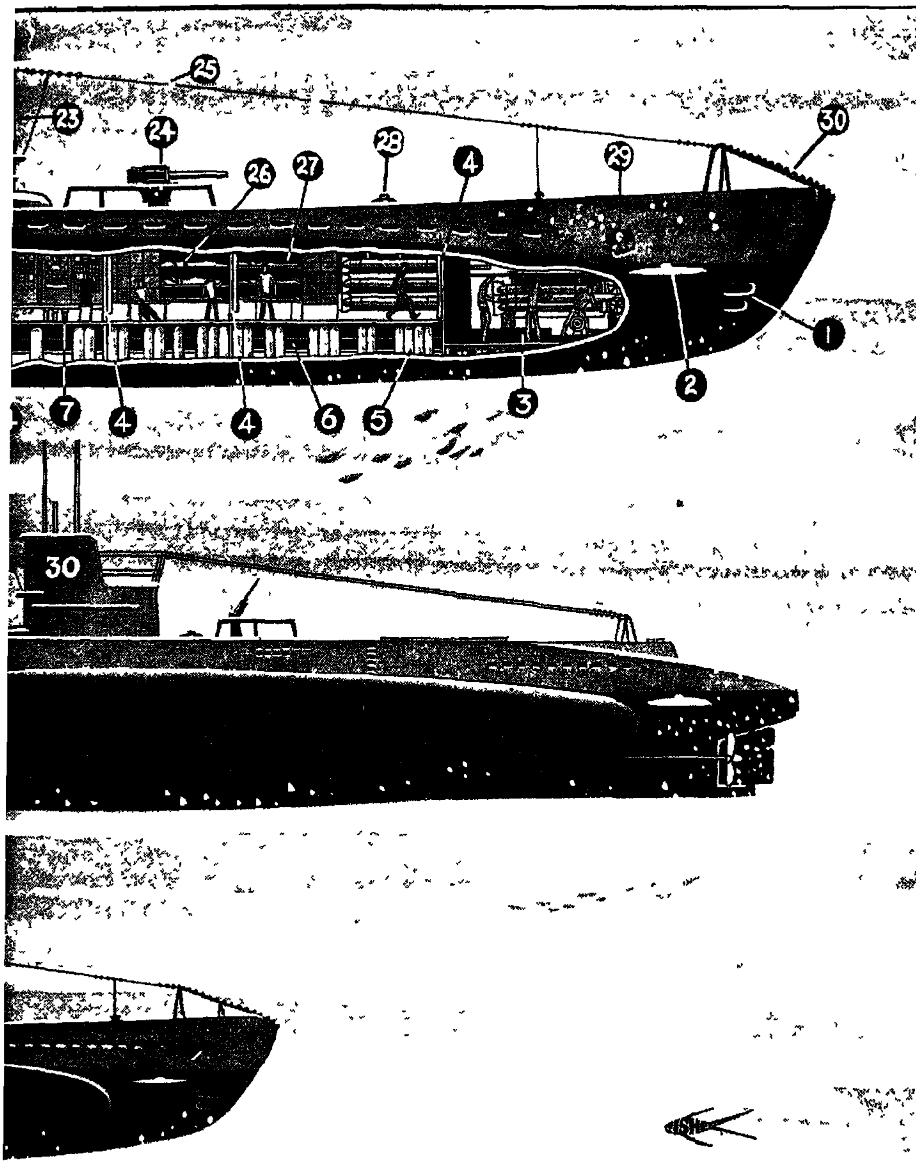
The temperature in a submerged submarine varies considerably. almost insufferably hot in summer, in winter it may be unbearably cold. These variations add greatly to the hardships of the personnel. Only picked men, chosen largely for their physical condition, can be employed in the submarine service It must be certain that they are able to withstand the strain of the work, for there can be no invalids on board The lives of the whole crew, too, depend on the accurate work of each individual member, so a high degree of skill is necessary, and each man must be able to carry out without supervision the duties that fall to his lot

The arduous nature of submarine work makes it necessary that the crew shall have a spell of rest between each




THREE TYPES OF U-BOAT

Fig. 2. (A) "*Atlantic*" *type* (*712 tons*), *six 21-inch torpedo tubes*, *4 1-inch gun*, *one-pounder anti-aircraft gun* (B) "*Seagoing*" *type* (*500 tons*), *six 21-inch torpedo tubes*, *3 5-inch gun* (C) "*Coastal*" *type* (*250 tons*), *three torpedo tubes in bow*, *one-pounder anti-aircraft gun* *Key to* (A) *1*, *Forward torpedo tube caps* (*two port*, *two starboard*) *2*, *Forward hydroplane* *3*, *Forward torpedo flat* *4*, *Watertight bulkheads and doors* *5*, *Compressed air bottles* *6*, *Battery tanks* *7*, *Main switch room* *8*, *Control room* *9*, *Quick-diving tanks* *10*, *Main*




USED IN THE GERMAN NAVY

*ballast tanks 11, Auxiliary engine room 12, Ballast tanks behind which are the oil fuel tanks 13, Main motors for cruising submerged 14, Starboard propeller 15, Vertical rudder 16, Aft hydroplane 17, Aft torpedo tube caps (two) 18, Aft torpedo flat 19, Aft rescue buoy 20, Main engine room 21, Officer's quarters 22, One-pounder anti-aircraft gun 23, Conning tower 24, 4 1-inch gun 25, Wireless aerials 26, Officers' quarters 27, Crew's quarters and torpedo storage 28, Forward rescue buoy 29, Anchor 30, Net cutter*

A SUBMARINE RETURNS TO HER "MOTHER"

**Fig. 3.** *The depot ship means rest and recreation to the crew of the submarine that is moored alongside her The submarine itself will be completely overhauled and repairs carried out*

patrol, and for this reason each vessel has a duplicate crew, the two crews manning the ship in turns Submarines are attached to depot ships, and these normally remain at a base (Fig. 3). When a submarine returns to her depot ship the men immediately move to more comfortable quarters on board the latter Here each crew has its own mess table, and the men are able to obtain the much-needed baths, exercise, and recreation that have been unattainable dreams during their spell of duty Meanwhile, the crew of the depot ship undertakes any maintenance work and repairs that may be necessary for the submarine. Fresh food is taken on board when the submarine sets out for a period of duty, but this is consumed all too soon, and thereafter the crew must live on a diet of tinned foods until the welcome day of their return to the "mother" ship.

The submarine's method of propulsion is dictated by the peculiar conditions under which it works. While on the surface the vessels are driven by Diesel engines (Fig. 4), which also turn the dynamos that charge large electric storage batteries Great care is taken in constructing these accumulators to make sure that the leaden lining is flawless, so that the acid contained in the cells may not find its way through any cracks and thus come into contact with the steel plating of the adjacent ballast or fuel tanks, or the hull of the submarine. If it did, the steel would be corroded and punctured with disastrous results.

But internal combustion engines, like human beings, require air, and air is unobtainable when the vessel is submerged The electricity which has been stored in the accumulators is used to drive the dynamos, which now function as electric motors, and provide the power to propel the vessel underwater These

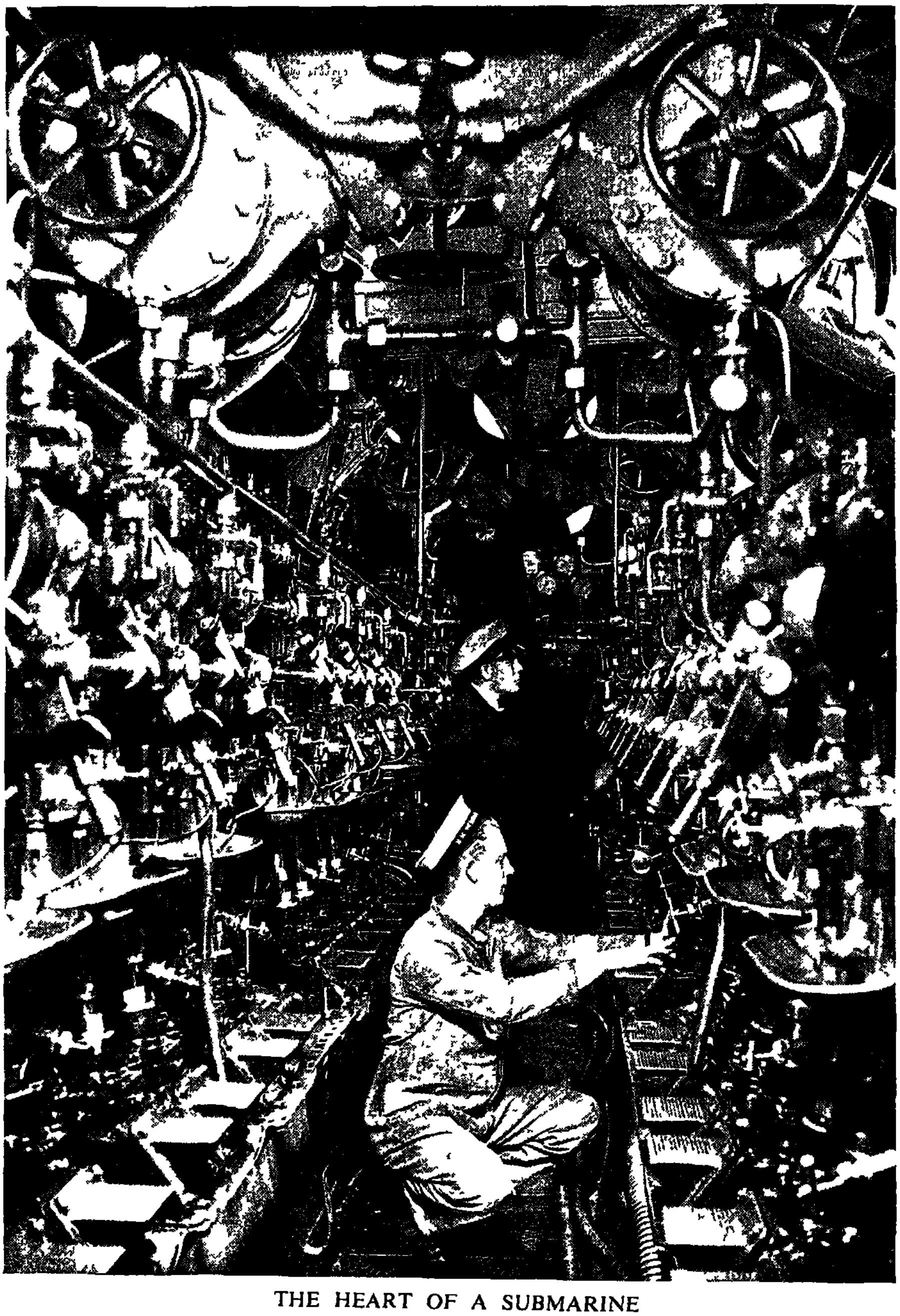
motors are in line with the surface propelling machinery and the propeller shafts. Clutches mounted on the shafts enable either the oil engines or the electric motors to drive the propeller shafts, either separately or together. At the same time, both sets of engines may, when desired, be entirely disconnected from the propeller shafts, so that the Diesel engines can be used to recharge the batteries when the vessel is lying stationary on the surface. Although a submarine can remain submerged without using power from the accumulators, the distance she can travel under water is, naturally, limited—normally to about sixty hours running. So, too, is her speed. it is rarely higher than ten knots, and usually less.

When a submarine submerges, she does not necessarily go down into the depths of the ocean, usually she will be only thirty to forty feet below the surface, known as "periscope depth." The effective length of a submarine's periscope is from thirty to forty feet, and at a greater depth than this she loses her "eyes" Moreover, the pressure on the hull of the submarine increases with her depth, so that if she goes too low she is in danger of being crushed like an eggshell by the surrounding waters. Some of the larger submarines can descend to a depth of over two hundred feet if necessary, but the average maximum depth is less than this

### METHOD OF SUBMERGING

It does not take long for a modern submarine to submerge: some can submerge completely within about thirty seconds. A submarine on the surface is kept buoyant by the air within it Part of its interior is taken up by buoyancy tanks, and if these are completely filled with water the vessel becomes heavier

SUBMARINE'S CRAMPED QUARTERS AND THE DEPOT SHIP'S SPACE
*(Left) Petty officers make the best of their tiny wardroom aboard the submarine (Right) In their recreation room on the depot ship, the officers enjoy much-needed relaxation*



THE HEART OF A SUBMARINE

**Fig. 4.** *Tending the powerful Diesel engines which drive the "sub" when on the surface and turn her dynamos Precision, accuracy, and a keen eye are needed for this job*

than a quantity of water equivalent to the vessel's own bulk, and therefore sinks rapidly. If the amount of water let into the tanks is only just enough to make the submarine's weight equal to that of an equivalent bulk of water, she will not sink far below the surface

### AIR AND WATER VALVES

The buoyancy tanks have valves at top and bottom, the former for air and the latter for water. When a submarine is on patrol, she will generally be cruising on the surface with the bottom valves open and the top shut The air in the tanks just equalizes the pressure of the water entering through the lower valves When the submarine has to submerge, the upper valves are opened, the air escapes through them, and water enters by the lower valves (Fig. 5) The electric motors are started, the hatches closed, and the vessel sinks rapidly below the surface.

When the vessel has submerged the top valves are shut, so as to be ready when it is desired to re-surface. Re-surfacing is effected by admitting compressed air through the top valves, thus forcing the water out of the bottom valves. (The compressed air containers, like the accumulators for the engines, are replenished when the submarine is cruising on the surface )

Once the conning tower is above the surface (Fig. 5) the hatch (1) is opened and pumps (2) draw in fresh air and force it into the tanks (3) through a valve (4). The ballast water is forced up a tail pipe (5) and out through a valve (6) The air vent (7) relieves pressure in the tanks when empty. "Positive" buoyancy, that is a condition when the submarine is made to "float" at any desired depth, is maintained by the internal tanks (13). The main pressure is taken by the external tanks (14) The saddle tanks (15) which help to preserve stability and to quicken submerging, are always open to the sea.

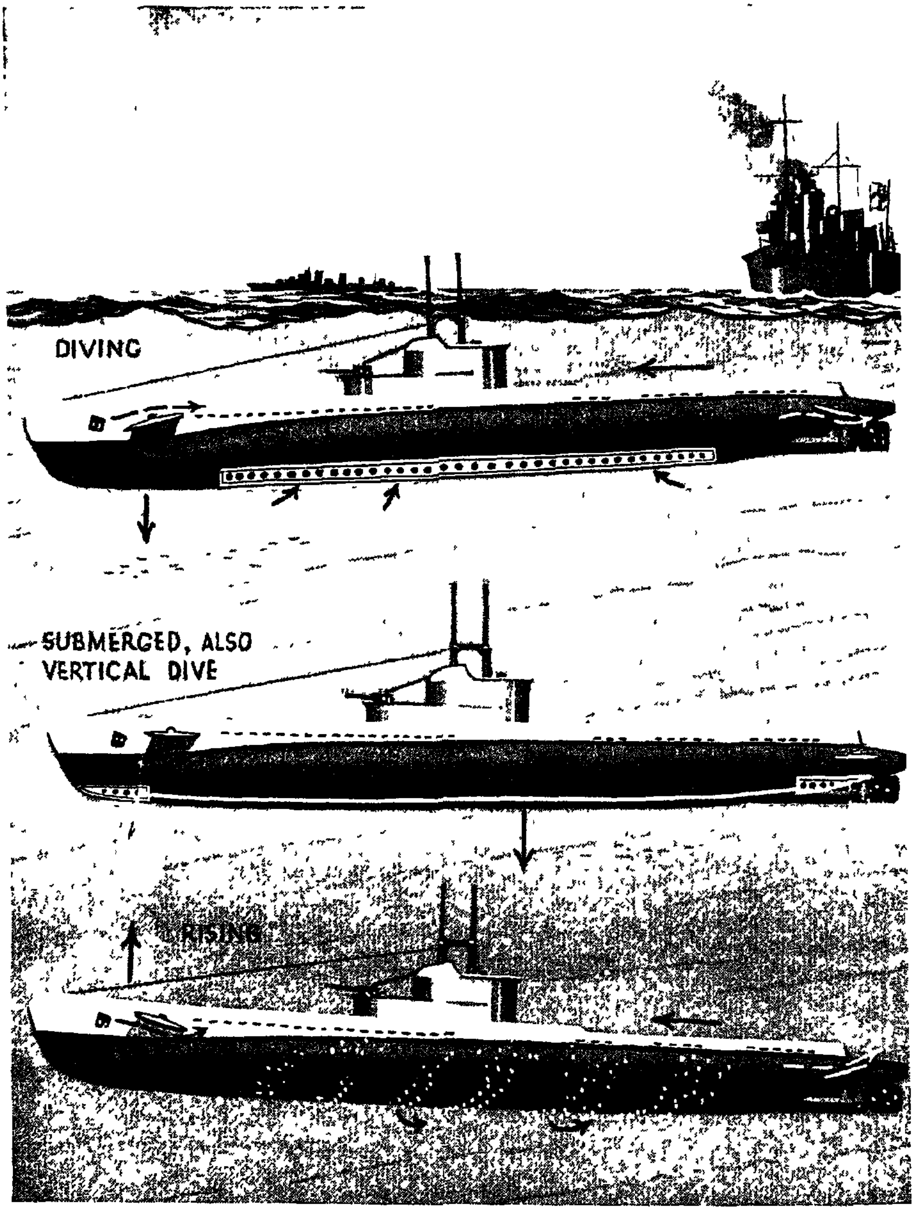
The submarine once submerged can be lowered to a greater depth or brought to the surface again by means of her motors and her hydroplanes Hydroplanes are diving rudders, like movable fins, attached fore and aft to each side of the vessel, and by tilting them suitably they can be made to control the submarine's depth when she is moving under the water.

Diving is usually performed by a combined use of the motors, hydroplanes and emergency tanks. The tanks can be so trimmed that the submarine will remain at any depth without her engines running, so that her presence cannot be discerned by submarine detectors (described later). The horizontal direction is controlled by an ordinary rudder

Someone (usually the captain) has to watch the objective by means of the periscope (Fig. 6). This is telescopic, and is raised by degrees as the vessel sinks lower and lower, only so much remaining above the surface of the water as is necessary to watch the enemy The top of the periscope tube is made as narrow as possible, so as to minimize the wake it leaves in the water as the vessel moves, but it must be robust enough to withstand the tremendous strain on it when the submarine is moving along with the tube extended at full length, it must also, of course, be completely watertight

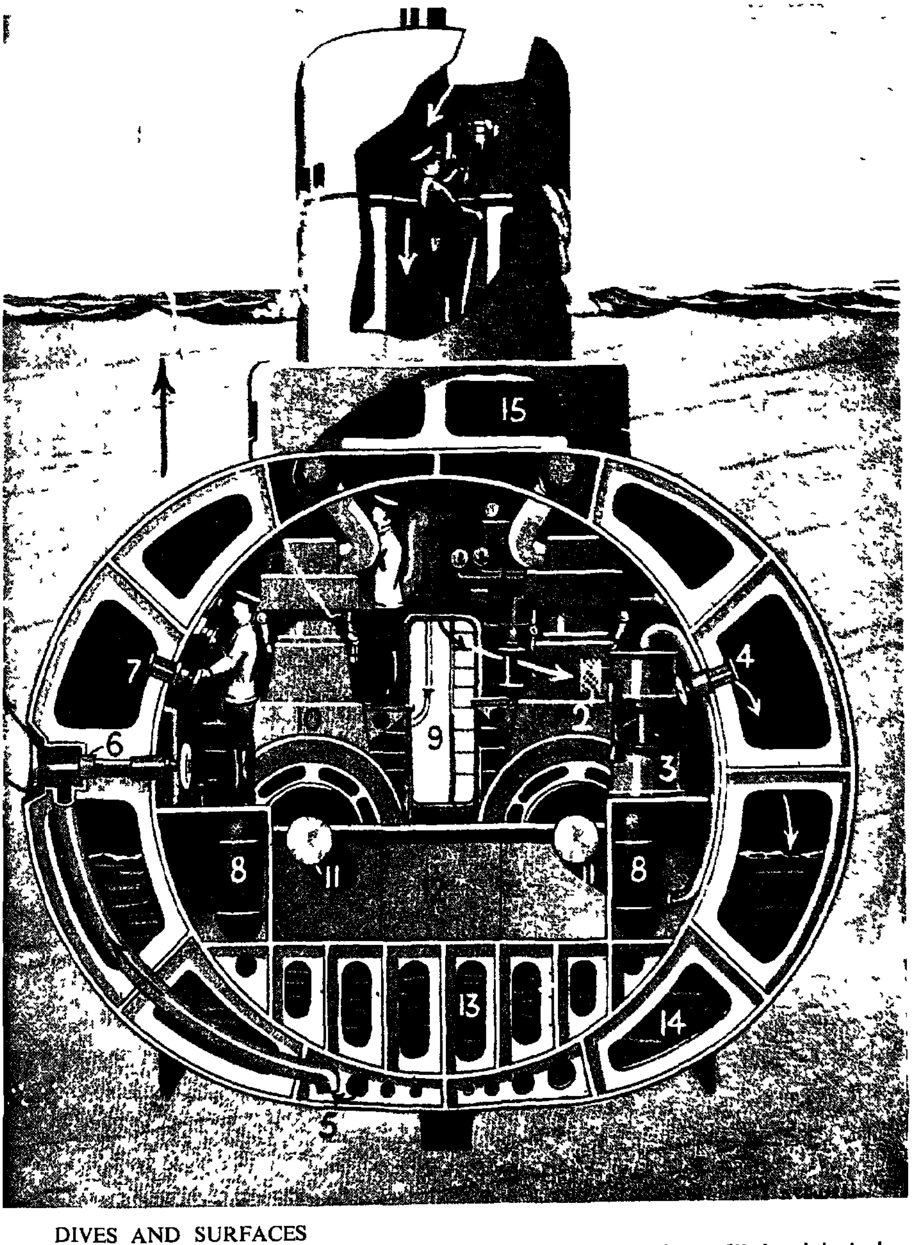
### PRINCIPLE OF PERISCOPE

A periscope, in principle, consists of two mirrors arranged in a tube at an angle (Figs. 7 and 8) In submarine periscopes reflecting prisms are used in place of mirrors, one at each end of the tube. Each prism faces an opening, and through the opening at the bottom the observer sees in the prism opposite him a reflection of the images picked up by the



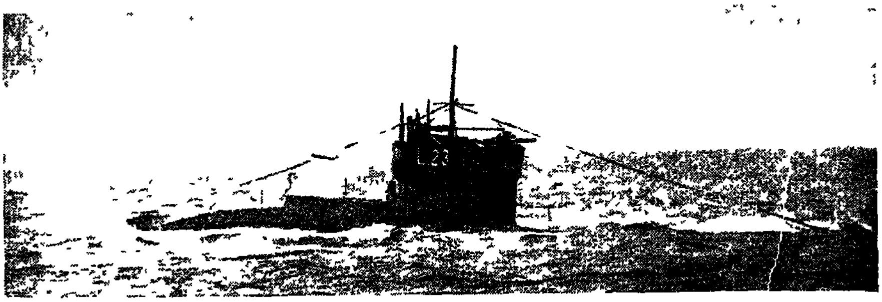

HOW A SUBMARINE

**Fig. 5.** *On right are details of submarine submerging gear (see text) greatly simplified for clarity 1, Hatch 2, Air pump 3, Pipes to tanks. 4, Blowing valve 5, Tailpiece 6, Outlet valve 7, Air vent valve 8, Compressed air bottles. 9, Watertight air door 10, Diesel engines 11, Propeller shafts 12, Electric storage batteries 13, Internal ballast tanks 14, External ballast tanks 15, Saddle tanks (emptied by gravity) On left a submarine is seen diving and*




DIVES AND SURFACES

*rising In diving (top) the ballast tanks (in the bottom of the vessel) are filled and the hydroplanes at either end are tilted, as shown When submerged (centre) the submarine is kept on an even keel by adjusting the water in the trimming tanks which are connected by a compensating pipe (white line) When rising (below) water is blown from tanks by compressed air and the hydroplanes reversed Compare with U-boat diagram on pages 276-277.*




"CRASH" DIVING TO ESCAPE ENEMY ATTACK

*Hatches closed, buoyancy tanks open, the submarine goes under, executing a "crash" dive. The propellers are almost above water as she submerges in a matter of seconds. Below, as the "sub" sinks beneath the waves, only the periscope remains above water. The submarine's cloak of invisibility is without doubt her greatest advantage*

prism at the top. The image is magnified by lenses, which also ensure sharp focusing, no matter to what length the tube is extended. Adjusting devices enable the area of the field of view and the degree of magnification to be varied, as with a telescope, and a scale attached to the instrument shows the bearing of an object, such as an enemy vessel, in relation to the submarine. When firing a torpedo while submerged—and a submarine is unlikely to fire one while on the surface—the periscope functions as a sight by which to aim the torpedo.

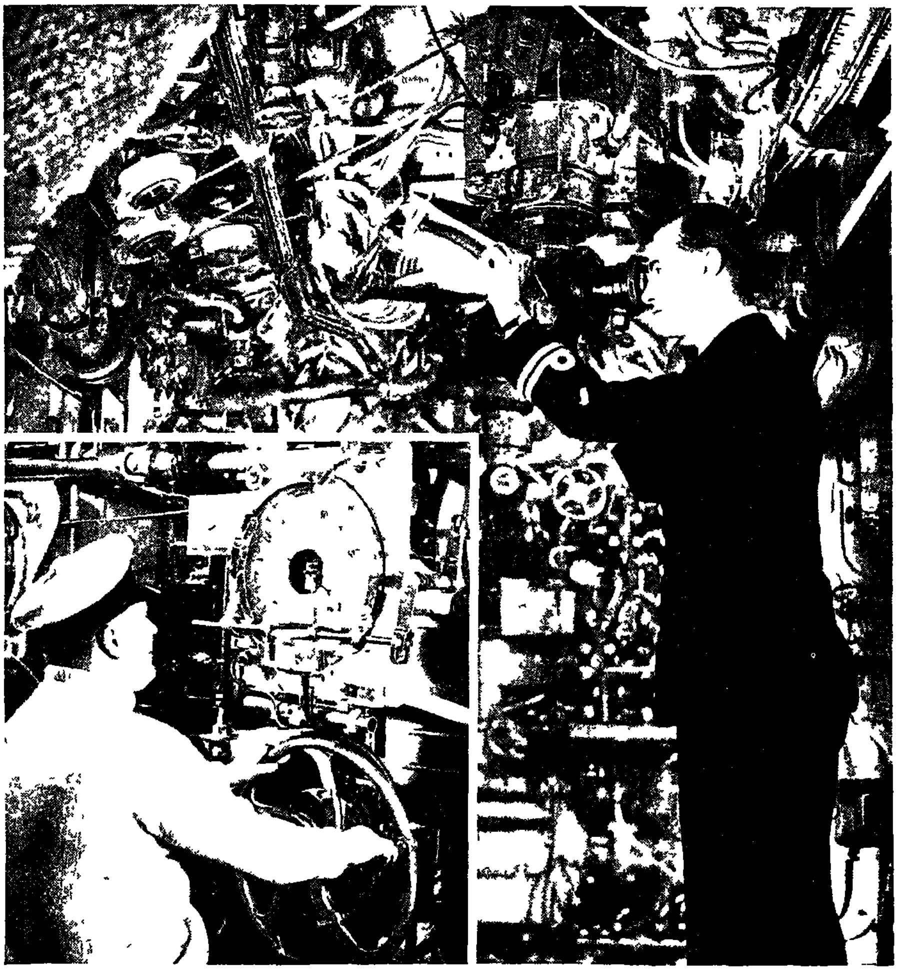
### SUBSIDIARY WEAPONS

For active defence purposes against small craft when on the surface, all submarines carry one or more guns (some of these guns can be seen in the illustrations on page 272). But the submarine's principal weapon of attack, as we have already seen, is the torpedo.

In most submarines, the majority, if not all of the torpedo tubes are in the bow (Fig. 9), so that the submarine must aim herself at the enemy vessel before discharging her torpedo, just as in aerial warfare a "Spitfire" or "Hurricane" aims its machine guns by aiming itself at the enemy aircraft.

### TAKING AIM

Since the torpedo will take a little time to reach the enemy ship, the submarine must aim slightly ahead of the ship, so that the two paths will meet, and she may have to trail an enemy for some little time before getting a suitable opportunity to fire her torpedo. A submarine's slow speed calls for considerable skill in manœuvring into posi-



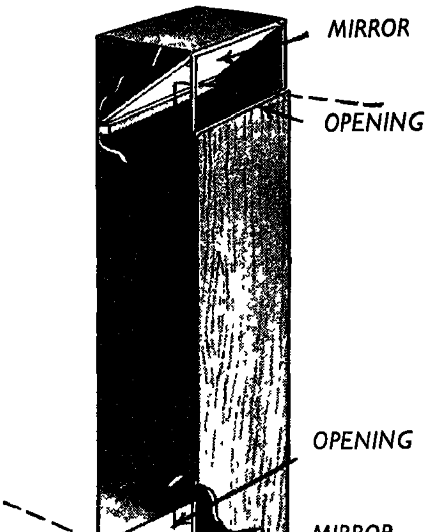
EYES OF A SUBMARINE

**Fig. 6.** *An officer at the periscope scans the surface of the sea, thirty feet above him. Inset shows the coxswain operating the hydroplanes which control a "sub's" angle and depth. The big gauge shows depth below the surface, and a spirit level on it indicates angle*

tion before it can fire its torpedo. Some aspects of this part of a submarine's duties are shown in Fig. 10.

From the standpoint of the distances at which naval engagements are fought, the torpedo is a short-range weapon, for it cannot be used with reasonable chance of success at more than, say, five miles. The farther it has to travel, the greater the chance that the ship which is its target will alter her course during its journey, though the modern torpedo's speed is anything up to forty-five knots, or even more. In clear water, too, a torpedo's approach can often be detected, though the method of propulsion now in use—of which more later—makes this less easy than with earlier types, which left a trail of air bubbles behind them.

Torpedo tubes of a submarine are




PRINCIPLE OF THE PERISCOPE

**Fig. 7.** *A periscope is actually only two mirrors arranged in a tube at an angle The picture seen by the top mirror is reflected to the lower one, and so to the viewer's eye*

always loaded before she leaves port, so that they are ready for immediate use. Additional torpedoes are stored in low racks, or "cradles," near the tubes through which they are to be fired

**LOADING A TORPEDO**

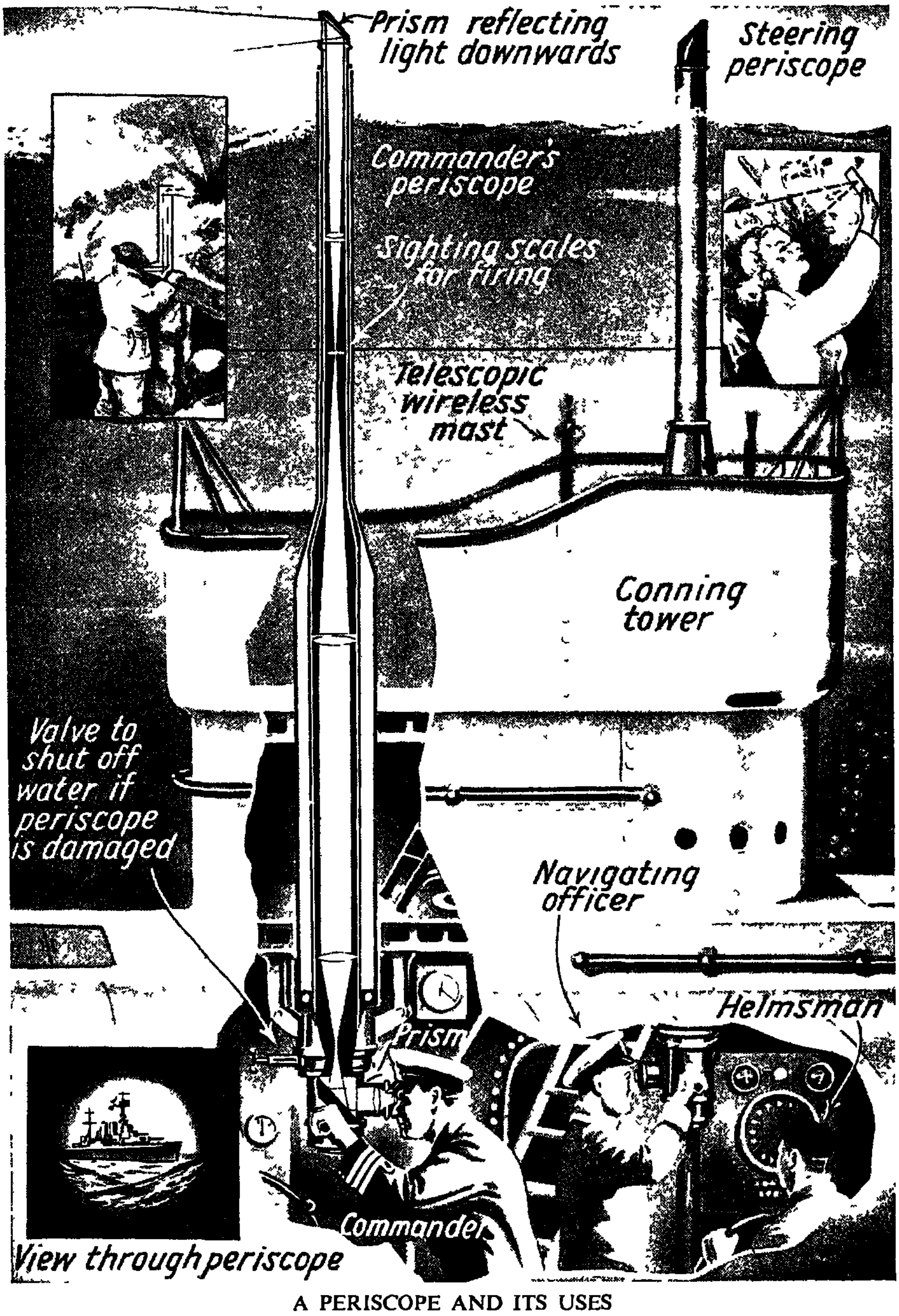
To load a torpedo tube, the circular door, or breech block, at the rear of the tube, is unlocked, the torpedo swung off its cradle, lifted, and hauled into the tube, and the door closed (Fig. 11). A small cap covers the mouth of the torpedo tube to keep out the sea, and when the torpedo is to be fired, this cap is swung clear by electrically-controlled gear. It is automatically replaced immediately after firing. The torpedo is fired by compressed air, maintained in a reservoir at the required pressure. A pistol grip is used for the actual firing. So delicate is the trim of a submarine when submerged that careful handling is needed to prevent her nose rising as a torpedo is fired and its weight suddenly released from the vessel As the torpedo leaves the tube, a trigger on it is actuated by the tube, and sets its internal mechanism in operation. Torpedoes from surface vessels, such as destroyers, are discharged above water level by means of a small charge of cordite (Fig. 12), and drop into the water after discharge.

**DETAILS ABOUT TORPEDOES**

Most of the torpedoes used in the Navy today are twenty-one inches in diameter. Only about a fifth of their bulk, however, is taken up by their explosive charge (Fig. 13). The remainder is occupied by the driving mechanism, steering gear, and buoyancy compartment, the last being necessary to give the torpedo that buoyancy without which it would sink to the bottom of the sea before reaching its objective.

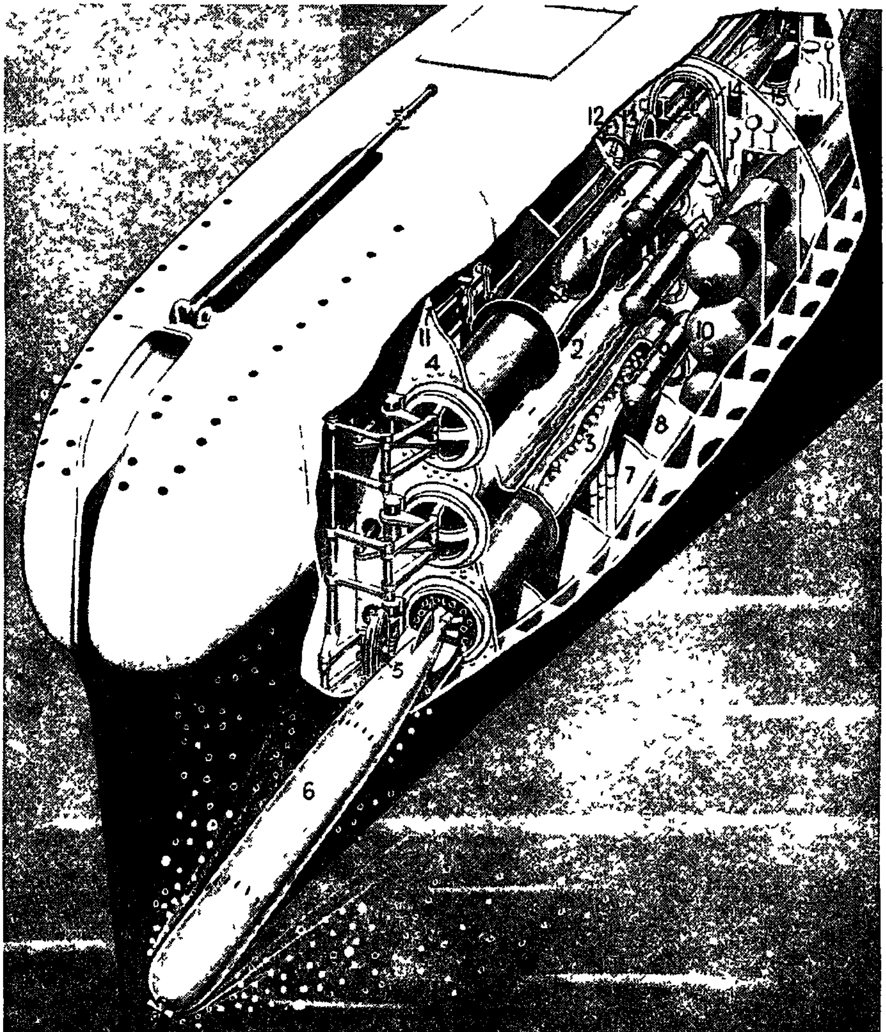
The projectile, which travels a few feet below the surface of the water, is kept level by the combined effects of a pendulum and a hydrostatic valve If the torpedo dips, the pendulum causes the fins which control its depth to move The hydrostatic valve, which is extremely sensitive to the variation in water pressure at different depths, will likewise cause the fins to move if the torpedo fails to maintain its proper depth.

But the torpedo must not only be maintained at the right depth, but must be kept on a straight course. This is done by a gyroscope driven by compressed air and connected to the rudder. This gyroscope consists of a small flywheel, about 2 lb. in weight, mounted in gimbal rings to give it the necessary



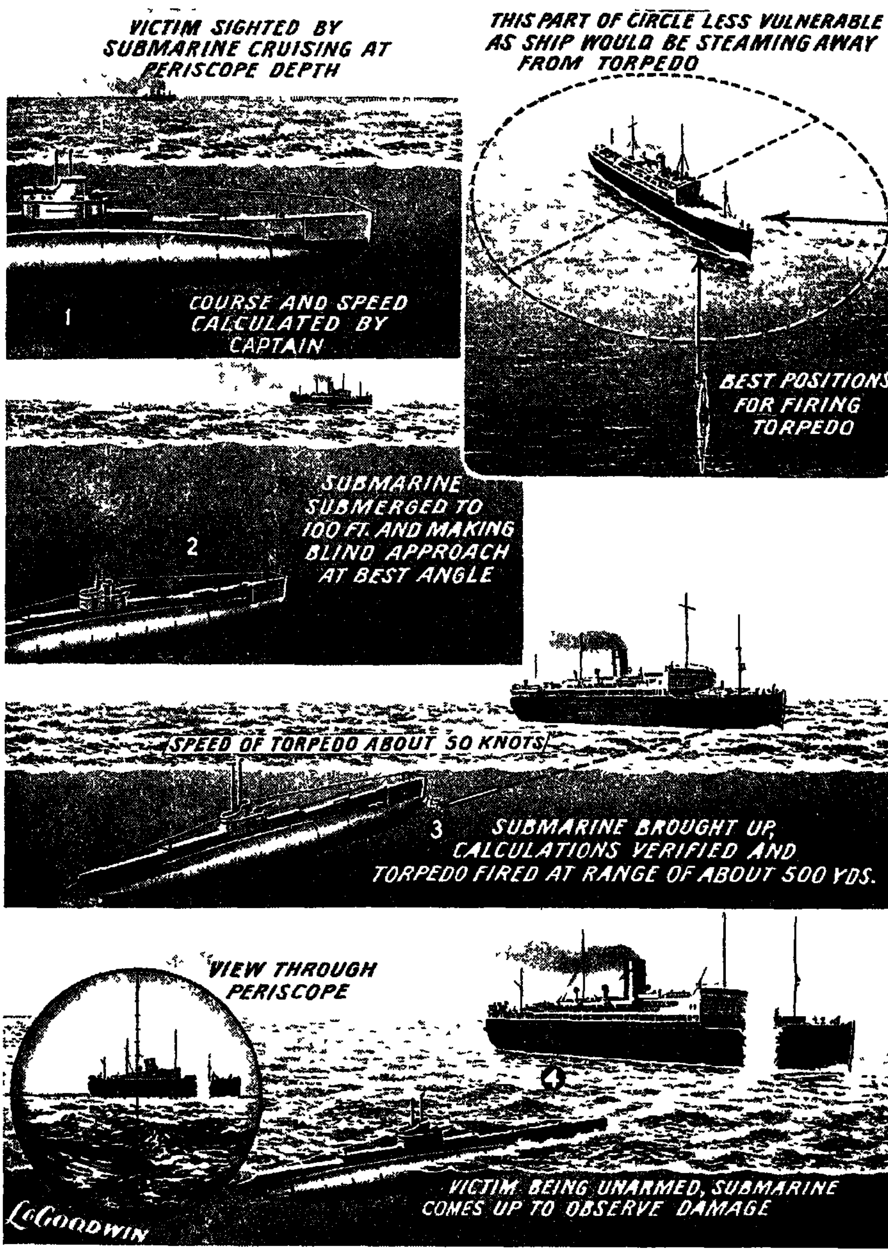

A PERISCOPE AND ITS USES

**Fig. 8.** *How the prism is used in the periscope, an instrument which permits us to make observations while submerged, as in a submarine (below) or as in a trench (top left)*




HOW A TORPEDO IS FIRED FROM A SUBMARINE

**Fig. 9.** *Here, in diagrammatic form, is shown the method of firing torpedoes from a submarine The three principal operations are shown in the three port torpedo tubes of a modern British submarine There are, of course, three other tubes on the starboard side The torpedo is the most destructive weapon known today and a salvo of three would cost about £6,000 Each one is an extremely complicated and costly piece of mechanism 1, Torpedo being loaded into tube, front cap closed, back open 2, Both caps closed and tube being flooded to outside sea pressure 3, Front cap opened and torpedo being fired by compressed air, after firing the front cap is closed and the tube pumped dry ready to load again 4, Front tube caps 5, Front tube cap open 6, Torpedo lea ' 'g tube 7, Draining and flooding tank 8, Forward trimming tank 9, Compressed air firing cylinder 10, Compressed air storage 11, Telemotor for operating tube caps 12, Tube cap operating wheel 13, Rear cap open 14, Watertight door to shut off the compartment 15, Torpedo handling and storage compartment*




HOW GERMAN SUBMARINES CLAIM THEIR VICTIMS

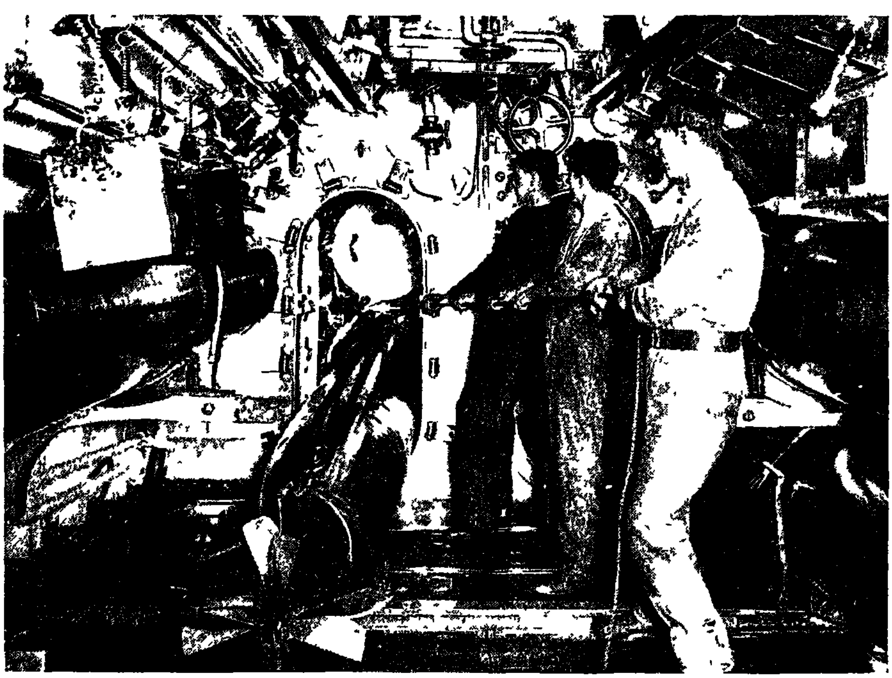
**Fig. 10.** *A commander observing international law would give due warning before firing his torpedoes, so that crew and passengers might take to the boats On the occasions when British submarines have destroyed German merchant shipping great care has been taken to safeguard the lives of the German crews—a sharp contrast to Nazi ruthlessness*

freedom, and running at about 18,000 revolutions per minute While the torpedo is still in the firing tube, the flywheel is set in rotation by the release of a powerful spring and a jet of compressed air The starting speed of some 10,000 revolutions per minute is attained in about one-third of a second, and when this is reached the suspension of the flywheel is unlocked, allowing the steering gear to operate immediately

### HOW A TORPEDO IS STEERED

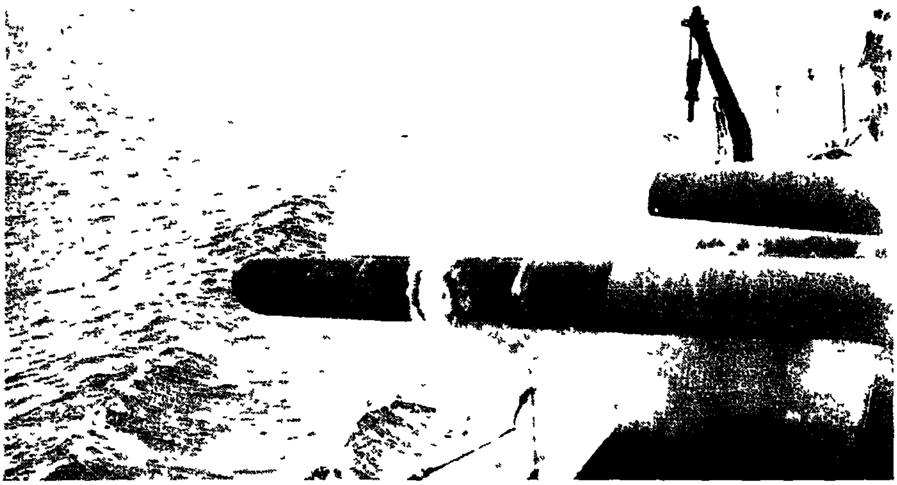
How does the gyroscope keep the torpedo to its intended direction? The principle involved is quite simple. It is that a spinning body offers considerable resistance to any attempt to deflect its axis from the position it occupied when the spinning movement began Even if freely mounted so as to be capable of moving in any direction, the axis of a rotating flywheel will continue to point in the same direction throughout its run. Thus, the flywheel of the gyroscope in the torpedo continues to rotate in the same plane as that in which it was turning when the torpedo left the tube If at any time during its course the torpedo deviates from the proper path, the gyroscope wheel will not turn with it, but will continue to rotate in its original plane As the torpedo turns around it, the gyroscope wheel is brought directly into contact with a cam. This operates a small slide valve which admits air to a steering cylinder, which in turn moves the vertical rudders and brings the torpedo back into line

The increased speed and range of the present-day torpedo have been largely made possible by a new form of propul-



LOADING £2,000 WORTH OF EXPLOSIVE

**Fig. 11.** *The torpedo has been swung from its cradle and is being hauled into the tube Each torpedo costs about £2,000, and is a complete assembly of 6,000 parts*



LAUNCH OF A TORPEDO FROM SURFACE CRAFT

**Fig. 12.** *The camera has caught the torpedo at the exact moment of leaving the tube, during practice on board H M S "Wakeful," British escort vessel, formerly a destroyer*

sion The engine was formerly powered by compressed air, but is now driven by a kind of superheated steam. Oil fuel burns in compressed air, the heat of the flame turning water into steam This, together with the products of the combustion of the oil, is fed to the engine The exhaust from the engine is brought out through the hollow propeller shaft and is largely dissolved in the water, so that there is little trace to betray the torpedo's approach

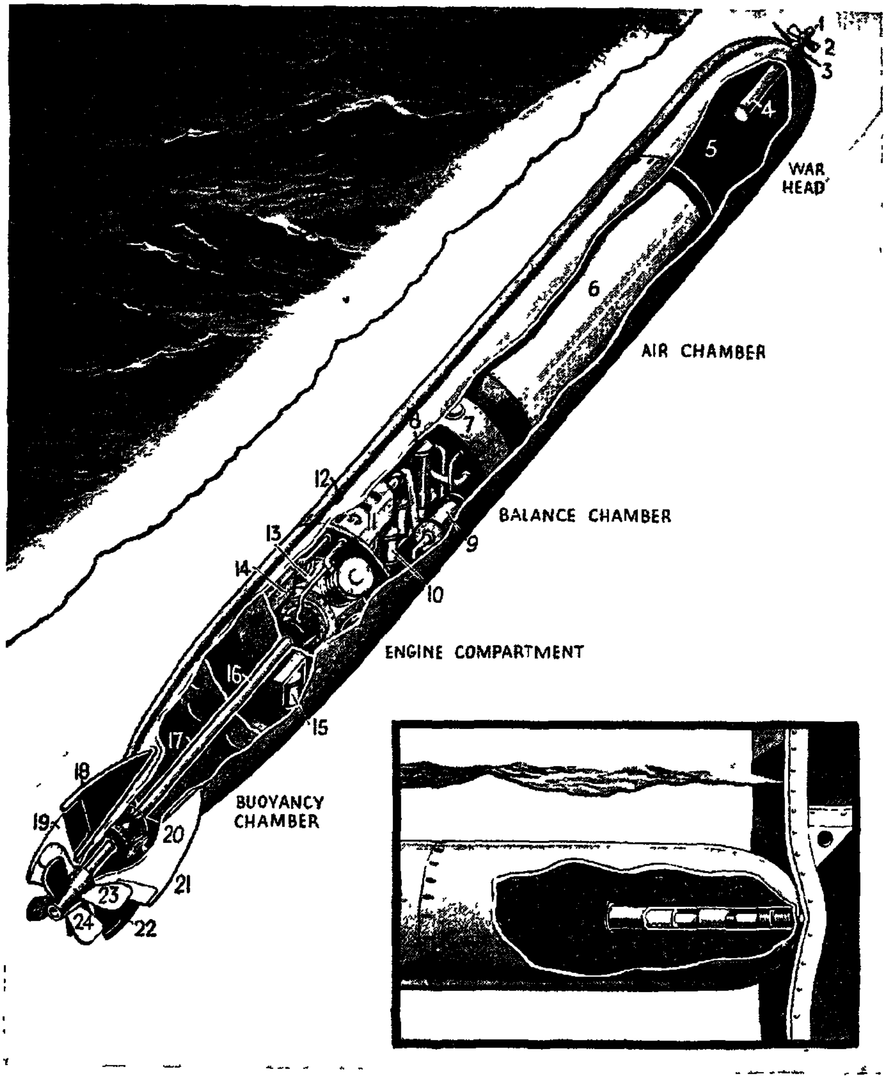
As soon as the torpedo's nose strikes a hard object, it explodes. The detonating mechanism is so designed as to operate only when it encounters a really solid object, for otherwise floating debris might explode the torpedo before it reached its target.

Since a torpedo explodes immediately its nose strikes its objective, it has none of the armour-piercing qualities of a shell. The deadly nature of the torpedo's threat to a ship is largely due to the fact that the damage it causes is below the waterline. Despite its death-dealing missiles and its cloak of invisibility, the submarine by no means has things all her own way. Defence measures for countering the submarine menace are now both many and varied

### USING THE DEPTH CHARGE

First and foremost comes the depth charge. This can be used without any elaborate special equipment, so that the smallest vessels can avail themselves of it. A depth charge is simply a container of high explosive (Fig. 14), that can be set to explode at any depth desired. In outward appearance it is very like a drum of oil, and can be slid into the water on runners over the stern of a boat Alternatively, it can be fired into the water from a kind of trench mortar (*see also* Fig. 14), which flings it clear of the vessel, to a distance of about forty yards. After dropping a depth charge, the vessel moves rapidly away, to be as clear as possible of the explosion, lest it, too, be damaged as well as the enemy submarine

Depth charges are laid in fours. First one is dropped astern, then, as the vessel




CONSTRUCTION OF THE MODERN TORPEDO

**Fig. 13.** *A 21-inch torpedo costs £2,000 and has 6,000 separate parts It is probably the most lethal weapon in existence 1, Firing pin 2, Safety screw 3, Whisker 4, Detonator 5, 500-lb high explosive 6, Compressed-air chamber 7, Water chamber 8, Hydrostatic depth control gear 9, Steering control for horizontal rudders 10, Paraffin bottle. 11, Trip valves and starting gear 12, Trigger starter 13, Four-cylinder hot-air driven radial engine of 350 h p 14, Servo motor 15, Gyroscopic rudder control 16, Propeller shaft, and 17, tunnel 18, Upper vertical fin and rudder 19, Port horizontal fin and rudder 20, Gearbox driving propellers in opposite directions 21, Starboard horizontal fin and rudder 22, Lower vertical fin and rudder 23, Forward propeller 24, After propeller Inset shows torpedo at moment of contact The safety screw has worked off during the torpedo's passage through the water, and the firing pin which operates the detonator is driven home by the impact*

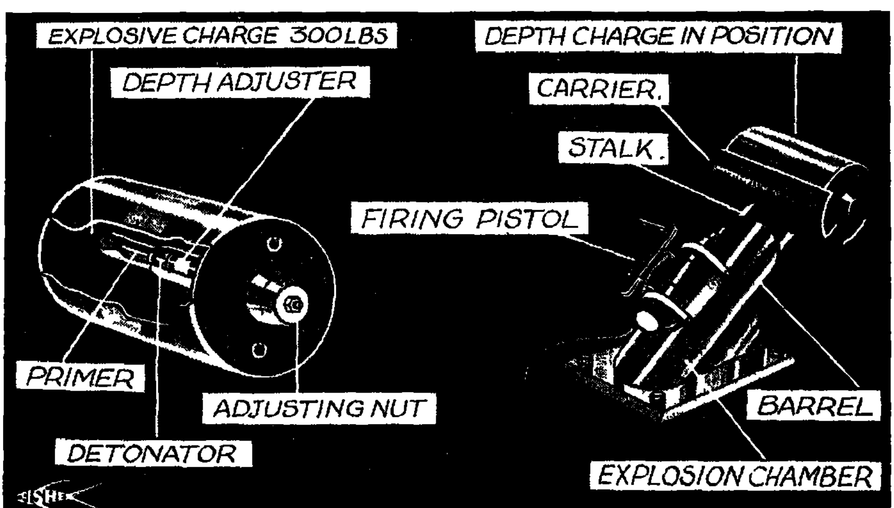
moves ahead, one is laid to port and one to starboard; finally, another is dropped astern to complete a diamond formation, shown in Fig. 15.

When depth charges are to be laid, the exact position and depth of the enemy submarine can be determined by the use of sound detectors. Depth charges may be set to explode at different depths, and they may inflict irreparable and fatal damage on a submarine without actually striking it. We have already seen that when a submarine is submerged to any considerable depth, the water exerts great pressure on its hull When to this pressure is added the tremendous force of the explosion of a depth charge, the strain may easily become too great, and her sides collapse. Even if there is no complete collapse, plates may be loosened so that the water penetrates, or some of the vessel's sensitive gear may be so damaged by the concussion that the submarine cannot re-surface.

When a submarine is destroyed by a depth charge, the fact is usually indicated to the attackers by quantities of oil and bubbles of air rising to the surface. This fact has given rise to what may be termed "camouflage" tactics. A submarine that is hard pressed may lie on the sea bed, if the depth be not too great, her engines silenced to prevent their noise disclosing her position to the sound detectors, and emit oil and air from her torpedo tubes Trapped submarines have been known in such circumstances even to shoot the caps of the crew from their torpedo tubes to deceive the attackers into the belief that they have scored a hit. Badly battered, the submarine may later find a chance to rise to the surface and crawl home to her depot ship.

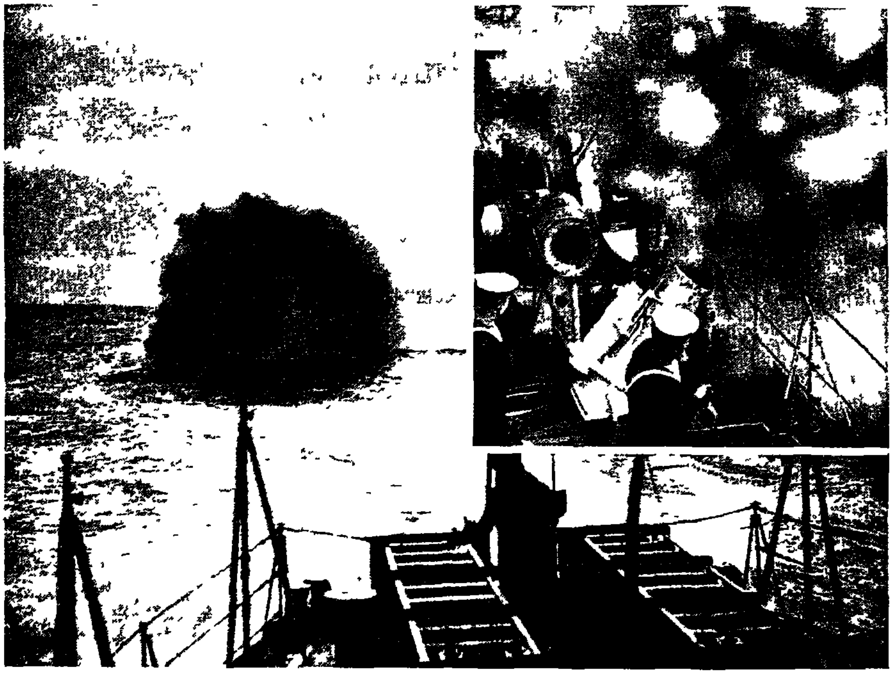
### TYPES OF SOUND DETECTORS

There are many types of sound detectors in use today, and most of their details are secret. Sound travels well in water, and no submarine can be silent when moving. Though her electric motors may be almost soundless when revolving slowly, the noise of the




CONSTRUCTION AND FIRING MECHANISM OF DEPTH CHARGE

**Fig. 14.** *The depth charge is really a very simple mechanism, consisting of a container of high explosive set to explode at a given depth (Right) Firing mortar and depth charge loaded*



THUNDER BELOW!

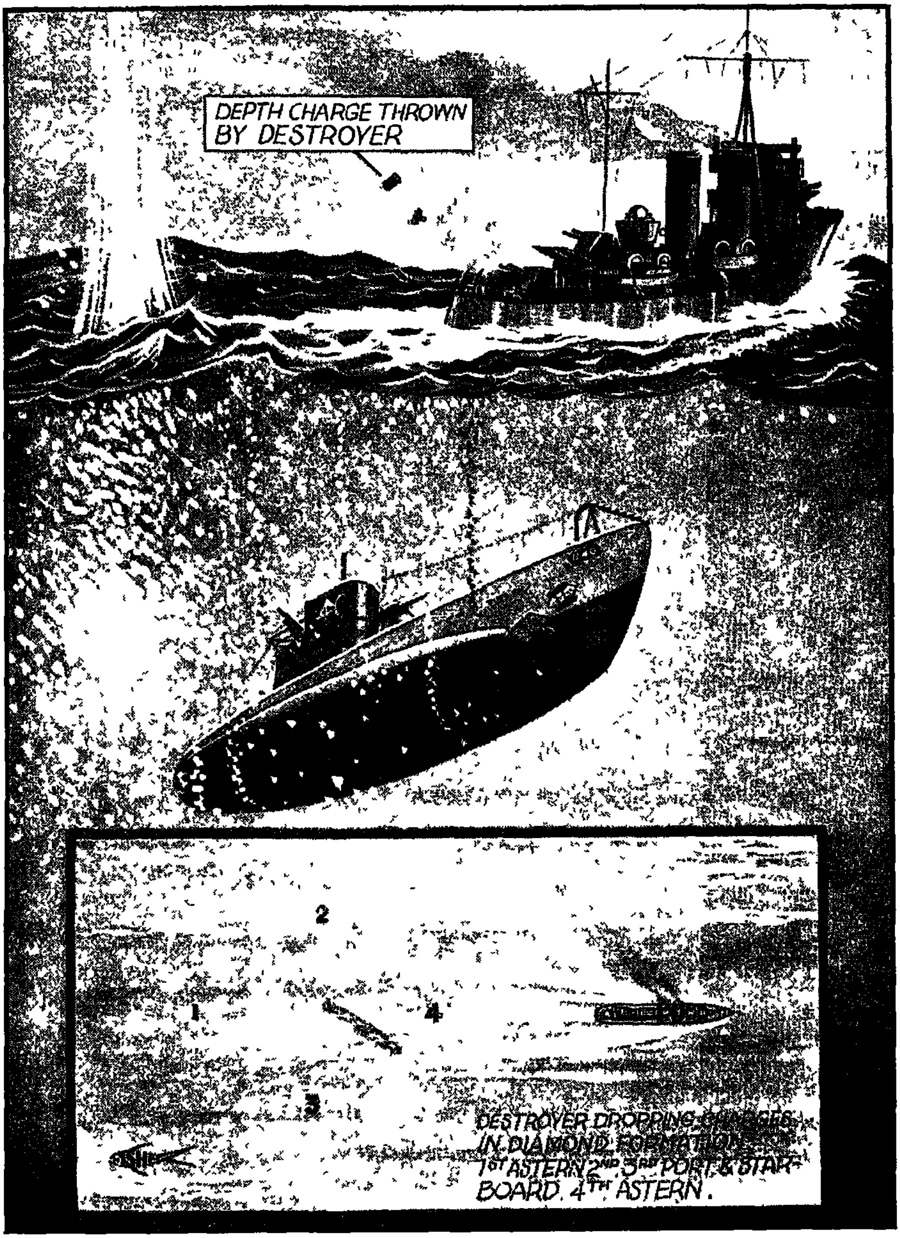
*A depth charge dropped by H M S "Bittern" explodes forty feet beneath the surface as the vessel moves away In the foreground can be seen the runners on which the depth charges are slid into the water (Inset) A depth-charge mortar is seen firing (see Fig 14, page 293)*

propellers turning in the water cannot be silenced The direction from which the sound comes is detected by a microphone fitted with a diaphragm. The strength of the sound will be greatest when the diaphragm is at right angles to its direction, and by using three such microphones simultaneously an enemy submarine can be located accurately and quickly Figs 16 and 16a show how

### DETECTING A SUBMARINE

The echometer—another device for detecting the distance of a submarine—depends for its utility on the principle that sound is reflected by a solid object A sound is made in the water by electrical means, and the arrival of its echo is listened for and electrically recorded Since the speed at which sound travels in water is known—it is about 4,900 feet per second—half the period of time, measured in seconds, between the making of the sound and the detection of the echo, multiplied by 4,900, will indicate the distance in feet of the object causing the echo.

Another anti-submarine device is the submarine net. This is generally used to protect the entrances of ports and harbours, and to prevent submarines from entering These nets, with their sinkers and supporting buoys, are laid by specially-designed ships with low, wide sterns over which the nets can be lowered into the water The nets consist of steel rings, each about ten inches in diameter, intertwined like the chain armour of the knights of old. They serve a twofold purpose they may




TACTICS OF DEPTH CHARGE ATTACK ON A SUBMARINE

**Fig. 15.** *This impression of an individual destroyer's part in destroying a submarine should be compared with the illustration on page 297, showing three destroyers working together Each destroyer drops its depth charges in groups of four, laid so that they form a diamond formation The explosion of a depth charge may cripple a U-boat, without actual contact*

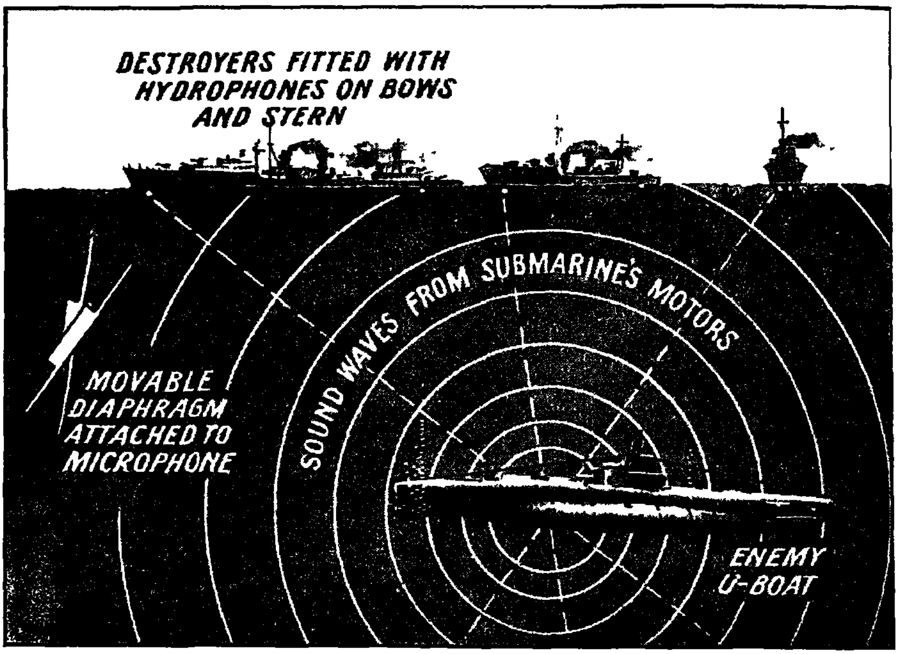



**Fig. 16.** *Principles of sound detection (for details see text)*

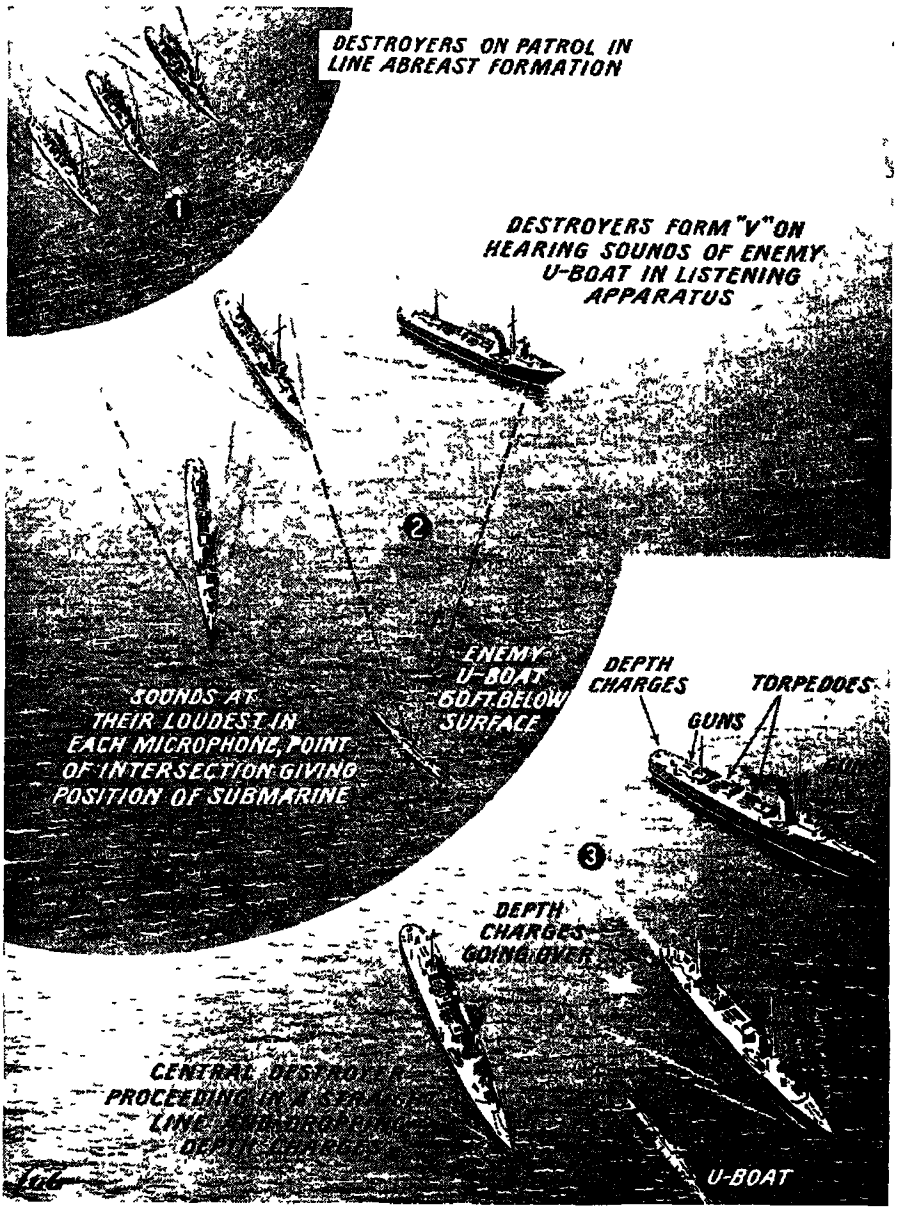
enmesh the enemy submarines and prevent their operation, or the mines attached to them may explode and damage or sink the submarines.

### PROTECTION OF HARBOURS

Harbours are also often protected from submarines passing near the surface by the laying of booms across their entrances with nets depending from them. Booms are also effective against small torpedo boats that might escape notice if they attempted to steal past by night. They are heavy enough to prevent a ship breaking through their construction, and are supported by stationary vessels.

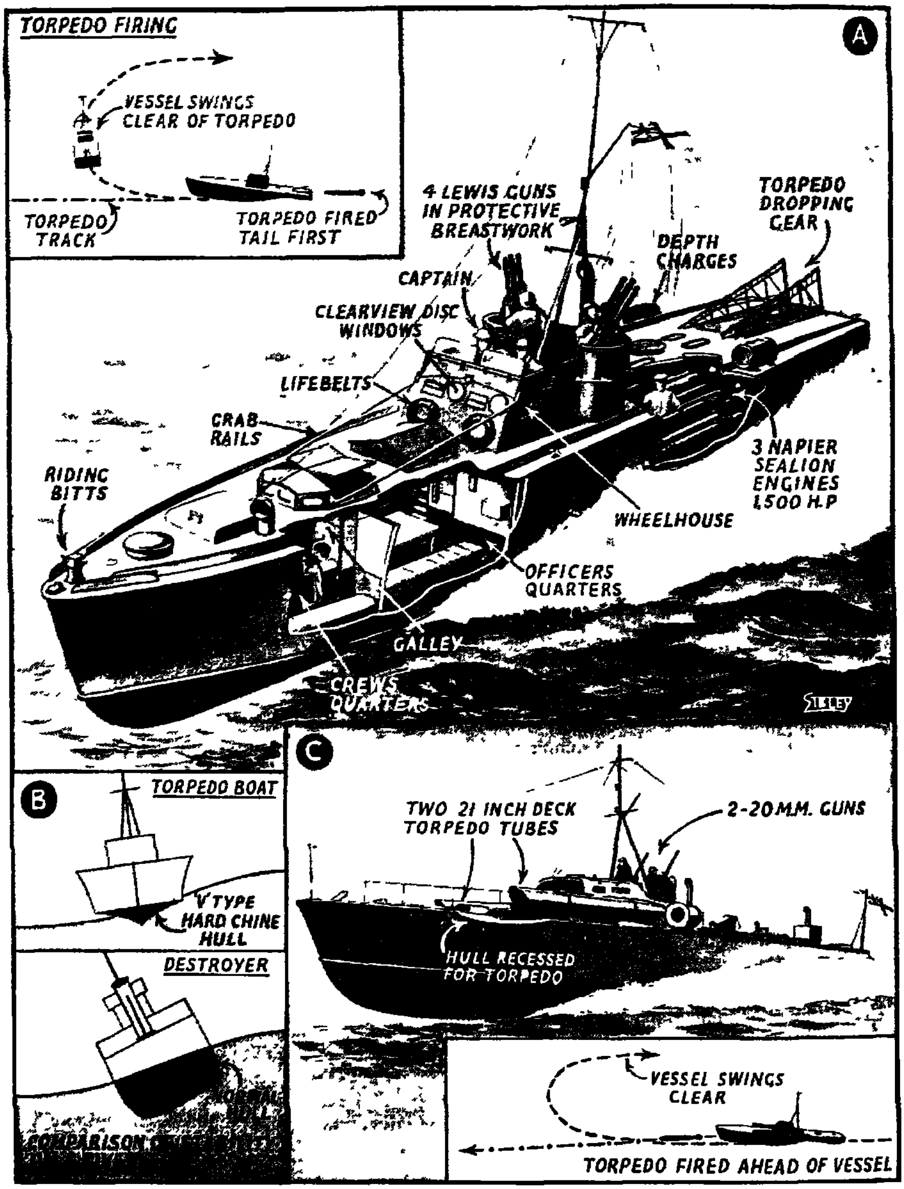
Though measures taken against submarines afford a large degree of protection against torpedoes (for the torpedo is the submarine's special weapon), they are not by themselves enough. Submarines cannot always be spotted and destroyed before they have fired their torpedoes, and these deadly weapons are carried also by other types of craft, such as destroyers and motor torpedo boats Steps have, therefore, been taken to provide warships with direct defence against the effects of torpedo attack. This defence takes the form of the "bulge" or "blister."

A warship's ordinary armour plating is designed to give it protection against shells and bombs. Though it is carried down some distance below the waterline, it is there intended to be a defence, not against mines and torpedoes, but against shells that, falling a little short of their target, hit the water before striking the side of the ship. We have seen earlier that the danger from mines and torpedoes is largely that water may enter through the holes they make Watertight bulkheads mitigate this danger, but more direct protection is




HOW DESTROYERS DEAL WITH THE U-BOAT MENACE

**Fig. 16a.** *The modern destroyer, properly employed, is just as fearsome a foe to the submarine as the latter is to any surface vessel. The destroyer "Sirocco," pride of the French Navy, sank three German submarines early in the war, proving that the underwater weapon is no longer the menace it once was. The above illustration shows how three destroyers (shown here closer together than they would actually be) can trap and destroy a U-boat.*




MODERN NAVAL WEAPON—THE MOTOR TORPEDO BOAT

**Fig. 17.** *Mainly developed and greatly improved since the war of 1914-18, the M.T.B. is a warship in miniature, with the added advantages of astonishing speed and manœuvrability. Handling these "mosquito craft" calls for lightning thought and unselfish team work, and the men who man them must possess the same mercurial type of personality as the pilots of Britain's "Spitfires." (A) Detail of the smaller type M.T.B., with inset, showing method of attack. (B) Hull comparisons. (C) Larger type M.T.B., with inset, showing operation*

given to the vessel if it is constructed with a false outer hull. This will take the full force of the explosion and greatly reduce the danger of the true hull being damaged sufficiently to permit much water to flow in.

The false hull at first took the form of a bulge or blister fixed outside the vessel from the waterline downwards, and some ships in the Royal Navy still have bulges of this kind (*see* page 188). Various measures, such as filling the bulges with a cork material, are taken to help them to dissipate the force of an explosion. But despite their streamlined shape, bulges were found to interfere with the speed and ease of manœuvring of the vessels to which they were fitted. Hence arose a further development: the "internal" bulge, built into the lines of the ship, the false hull maintaining the ship's natural line. Thus the speed and navigation of the vessel are in no way interfered with, and a large measure of protection is provided against the worst effects of, at any rate, a single hit.

### MOTOR TORPEDO BOATS

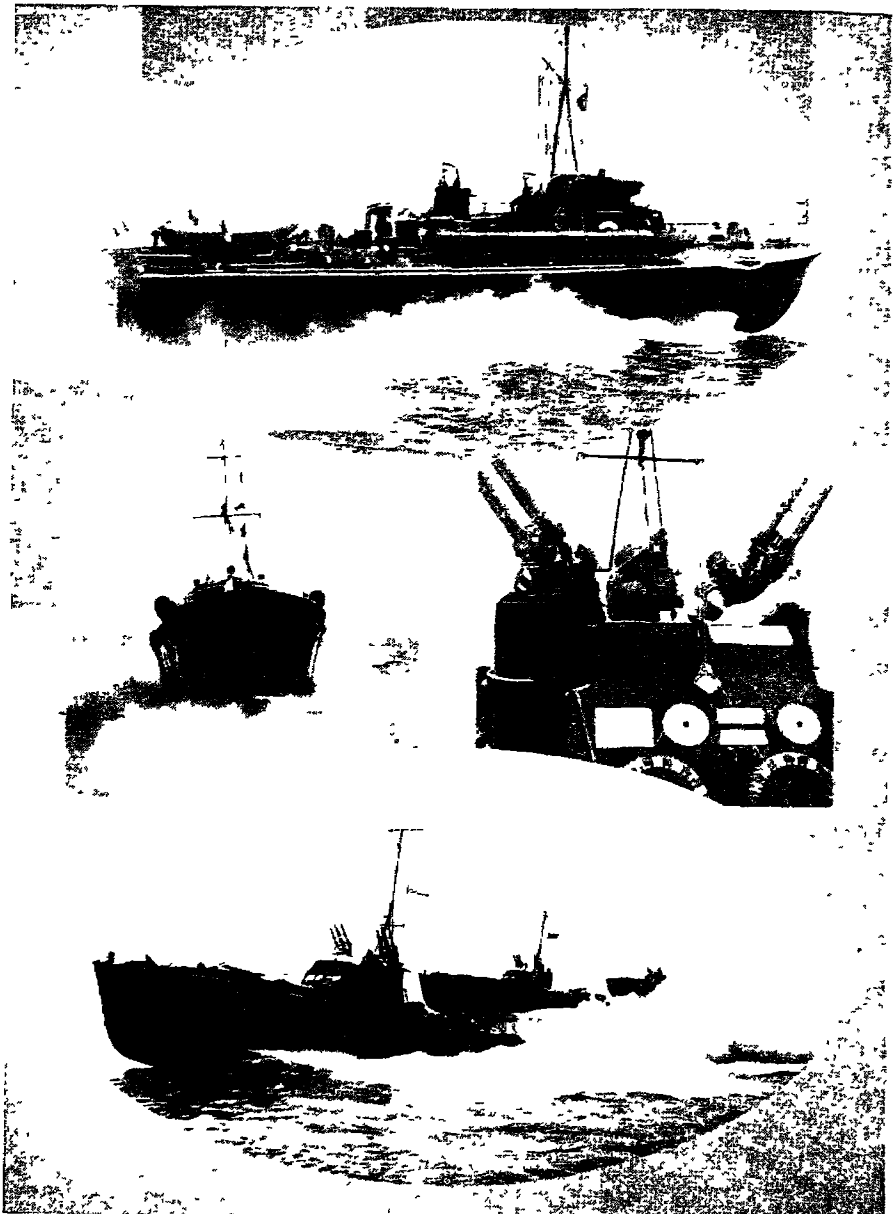
Earlier in this chapter we mentioned that there is now a type of surface craft whose main weapon, like that of the submarine, is the torpedo. This is the motor torpedo boat (Figs. 17 and 18), a small naval vessel first developed during the war of 1914-18, when for the concealment of their real purpose, these craft were officially called coastal motor boats. Its two distinctive characteristics are small size and high speed, and as it can also manœuvre rapidly, it is a difficult target for gunfire. For sudden attacks it may well prove a dangerous weapon. Its speed enables it to approach quickly from a distance out of range, its small size makes it difficult to spot, it can get into position quickly, discharge a torpedo, turn rapidly and retreat.

These mosquito craft are seagoing warships in miniature, and can make comparatively long sea passages unaccompanied by other craft. The complements, usually comprising two officers and eight men, have sleeping quarters and other amenities that men serving in submarines may well envy.

### ARMAMENT OF M.T.B.s

They carry guns of various types for self-protection: the smaller of the two boats of which details are available has eight Lewis guns (C, Fig. 18), while the larger has two 20-mm guns mounted together and capable of being trained in any direction, so that even the low-flying aircraft, which, given their speed and manœuvrability, would seem the most likely counter weapon against them, are likely to find these boats tough customers.

Earlier craft of this type carry two 18-inch torpedoes that can be slipped stern first into the water behind the boats, the larger and more modern types which have ordinary torpedo tubes firing forward (A, Fig. 18), carry two 21-inch torpedoes. Their shallow draught gives them immunity from both mine and torpedo attack, and, in conjunction with their speed, makes it easy for them to clear their own torpedoes after discharge. Into their tiny hulls—sixty feet in length in the smaller and about seventy feet in the larger types—are packed not only the living and sleeping quarters of the crew, wireless, and navigational equipment, stores, ammunition, and depth charges, but also three powerful petrol engines and their fuel. Each engine drives a separate propeller, an arrangement that tends greatly to ease of manœuvre. In the earlier craft (D, Fig. 18), the three engines have a total of 1,500 h.p. giving a speed of thirty-five knots. The larger boats, with at least double the horse power, can attain the high maximum speed of from forty-five to fifty knots.



'MOSQUITO CRAFT' WITH A TERRIFIC STING

**Fig. 18** *Faster than any other war craft, perfectly manœuvrable and formidably armed, the untested motor torpedo boat is destined to provide startling developments in naval warfare* (A) *Larger type M T B showing 21-inch torpedo tubes* (B) *This M T B makes a pretty picture as she speeds in the wake of a sister craft* (C) *The powerful eight machine gun armament* (D) *Three smaller type M T B s speeding at over thirty-five knots*

The great speed of these boats is made possible by the lightness of their hulls. These are so built that the boats draw less water when travelling at speed than when stationary. At speed the hulls are not driven through the water, but plane along on its surface. Were it not for the necessity of ensuring that they can remain at sea in fairly rough weather, they could have been given even higher speeds with the same engine power

But these new mosquitoes of the sea have not displaced the submarine as the main vessel for torpedo warfare. Of both torpedo and submarine it may be said that their lethal value varies considerably according to the scruple, or lack of it, with which they are used. Against merchant ships the submarine and its torpedo can be a most deadly foe, against warships, which can take highly effective counter measures, they are in a very different position. Indeed, the submarine that is operating against a fleet of warships is engaged in a highly dangerous task The comparative safety enjoyed by merchant ships under convoy shows that in most circumstances submarines are no match for surface warships

### SUBMARINE EPICS

But the submarine can find plenty to do in fair and legitimate warfare, as the lively cruise of H.M S. *Salmon* (*see* illustration on page 272), in December, 1939, well proved. Shortly after leaving on patrol in the North Sea, a German U-boat was sighted ahead, moving fast on the surface. The *Salmon's* torpedo tubes at once went into action the small and difficult target was hit, and the wreckage of the U-boat was hurled 200 feet into the air. A few days later the *Salmon* sighted the German Atlantic liner *Bremen*, and signalled her to stop. The signal was unheeded, enemy aircraft approached, and the *Salmon* had to dive. She could have fired torpedoes at the *Bremen*, a target that it would have been impossible to miss. But this would have meant that such of her crew as could have taken to the boats would have been left adrift on the open sea, which is contrary to international law and the practice of the British Navy. So the *Salmon* proceeded to search for better prey Twenty-four hours later she found it: the German battleships *Scharnhorst* and *Gneisenau*, a pocket battleship, probably the *Deutschland*, two heavy cruisers, and the light cruiser *Leipzig*

### SINKING A GERMAN CRUISER

Their course brought them into range, and the *Salmon* fired six torpedoes, slightly spread so as to give a chance of hitting more than one enemy ship. The first torpedo reached the *Leipzig*, two more explosions followed, indicating that another ship had been hit Depth charges were at once released against the *Salmon*, but she eluded them, and returned under cover of darkness to find the sea over an area of four square miles thickly coated with oil from the ships her torpedoes had damaged or sunk.

Perhaps the long-range reconnaissance aeroplane is the greatest menace to the submarine. Invisible from the surface as it may be, the submerged vessel may be spotted at a considerable depth from aircraft, especially in a calm sea

The appearance of enemy aircraft in the sky is usually the signal for any submarine in the vicinity to submerge immediately, and to stay under water until the danger is past

Yet with all its discomforts and dangers, the cramped, airless quarters, the lack of fresh food, the knowledge that to be trapped in a craft that cannot rise to the surface means, short of a miracle, a lingering death by asphyxiation, the submarine service of the Royal Navy has never been short of volunteers.


WINGS OF THE NAVY

*Aircraft today are the eyes of the fleet and have increased its range of action enormously This picture shows machines of the Mediterranean Fleet Catapult Squadron over Alexandria.*

## CHAPTER X

# THE FLEET AIR ARM

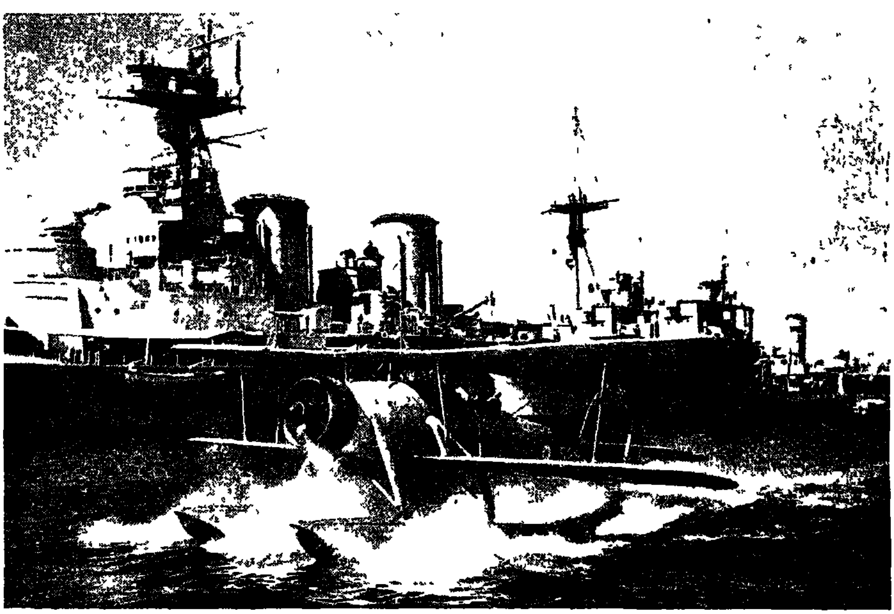
No longer is the Navy concerned with the surface of the waters alone: its field of action nowadays is three-dimensional. In another chapter we have seen something of its underwater activity here we must turn to that part of its business which is carried on in the air.

The Fleet Air Arm is not a distinct force—that is to say, it is not an independent air-fighting service for use over water, as is the Royal Air Force over land—but an integral part of the Navy Its duties are to assist the other branches of the Navy to fight and to patrol the seas Its work must not be confused with that of the flying boats and other aircraft of the Coastal Command of the Royal Air Force which operate mainly over water, but whose duties are primarily concerned with land defence.

The Fleet Air Arm, administered entirely by the Admiralty, started its independent existence on May 24, 1939, when the Navy took over complete charge of all sea-borne aircraft, whether in aircraft carriers or other warships.

The only relation between the F.A.A. and the R A.F is that the latter supplies aircraft to specifications given by the Navy, and also undertakes the preliminary training of F.A.A pilots, though that training is completed by the F A.A. itself, at its own training centres and shore establishments

The shore establishments of the F.A.A.



FAIREY "SWORDFISH" ALIGHTING AFTER A PATROL

*Grace and strength combine to give an impression of power in this picture of a Fairey "Swordfish" alighting after a patrol and passing H M S "Hood," the largest warship in the world*

are used both for the training of personnel and for the accommodation of seaborne aircraft when ashore. The Naval Discipline Act requires that all naval personnel must be borne on the books of a ship, and in consequence these shore establishments are given ship names When the German radio announced in October, 1939, that H.M S *Kestrel* had been successfully attacked by the German Navy and sunk, a good deal of amusement was caused among those "in the know"—for H M S. *Kestrel* is the official name of the Royal Naval Air Station at Worthy Down in Hampshire!

At the outbreak of war the headquarters of the Rear-Admiral Commanding Naval Air Stations were at the Lee-on-Solent Station, known in naval parlance as H M.S. *Dædalus*. Besides the *Dædalus* and *Kestrel*, there are two other Naval Air Stations in Great Britain—at Ford, in Sussex, and Donibristle, Fifeshire—known respectively as H.M.S. *Peregrine* and H.M S *Merlin*.

Since the Fleet Air Arm became entirely naval, it has acquired a personnel no less varied than that of the R.A F It has its own artificers, mechanics, and wireless operators, as well as pilots, observers, and air gunners

The pilots fall into one of three categories They may be fully-trained officers of the Executive Branch of the Royal Navy, or of the Royal Marines, who have chosen to specialize in air work, they may be short-service officers who enter the Navy specifically to become pilots, or they may be selected ratings The introduction of short-service commissions is a new departure for the Navy, though it has been a common practice in the R A F. for some time past. Although these short-service officers receive some nautical training, it is limited, and they do not qualify to take command of a ship. They wear a small letter A on their sleeves to indicate that they are members of the air branch of the Royal Navy Ratings of the Flying

SAILORS OF THE AIR IN THE MAKING

*The Navy maintains several shore training establishments Here are naval ratings learning to fly at H M S "Kestrel," the F A A training establishment at Worthy Down, Hampshire*

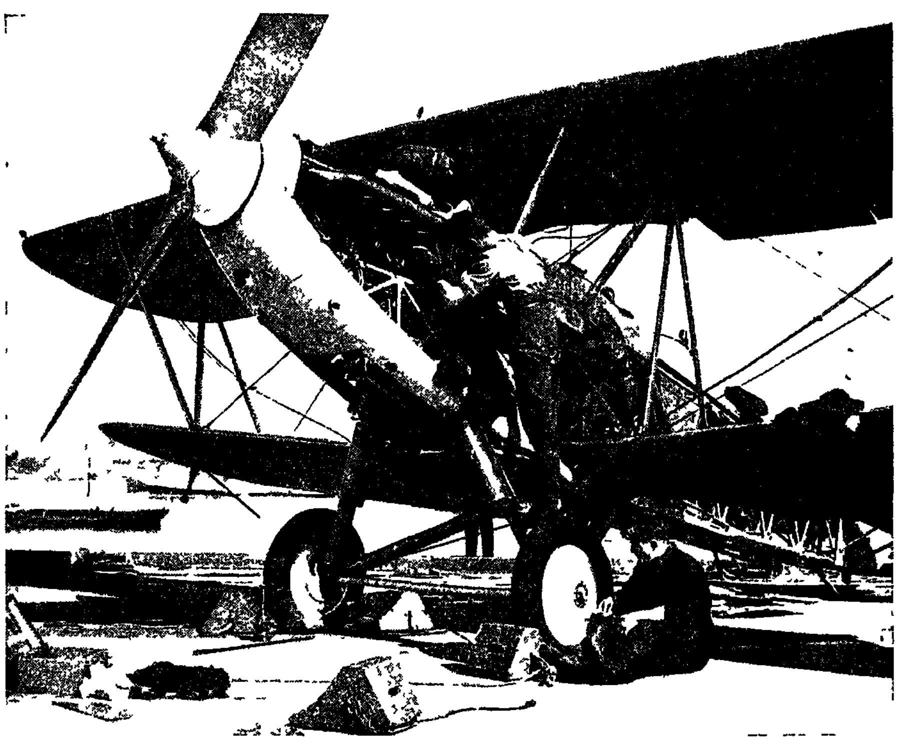
Branch are now graded as petty officer airmen, leading airmen, naval airmen first and second class, and boy airmen first and second class

Officers are also employed in the F A.A. as observers and as engineers. The observers may be either officers with short-service commissions, or officers with permanent commissions transferred from the Executive Branch. Engineer officers come from the Engineering Branch of the Navy. Ratings also act as observers and as air gunners The latter, who also fly in F A.A aircraft, not only man the guns of the aircraft, but act as wireless operators

The main duty of the observer is to navigate the aircraft This calls for a high degree of skill, for the aircraft will often be operating out of sight of its parent vessel, and the observer will have no land marks by which to check his position. He must be able to navigate well enough to find his ship again in such circumstances often after flights of a hundred miles or more.

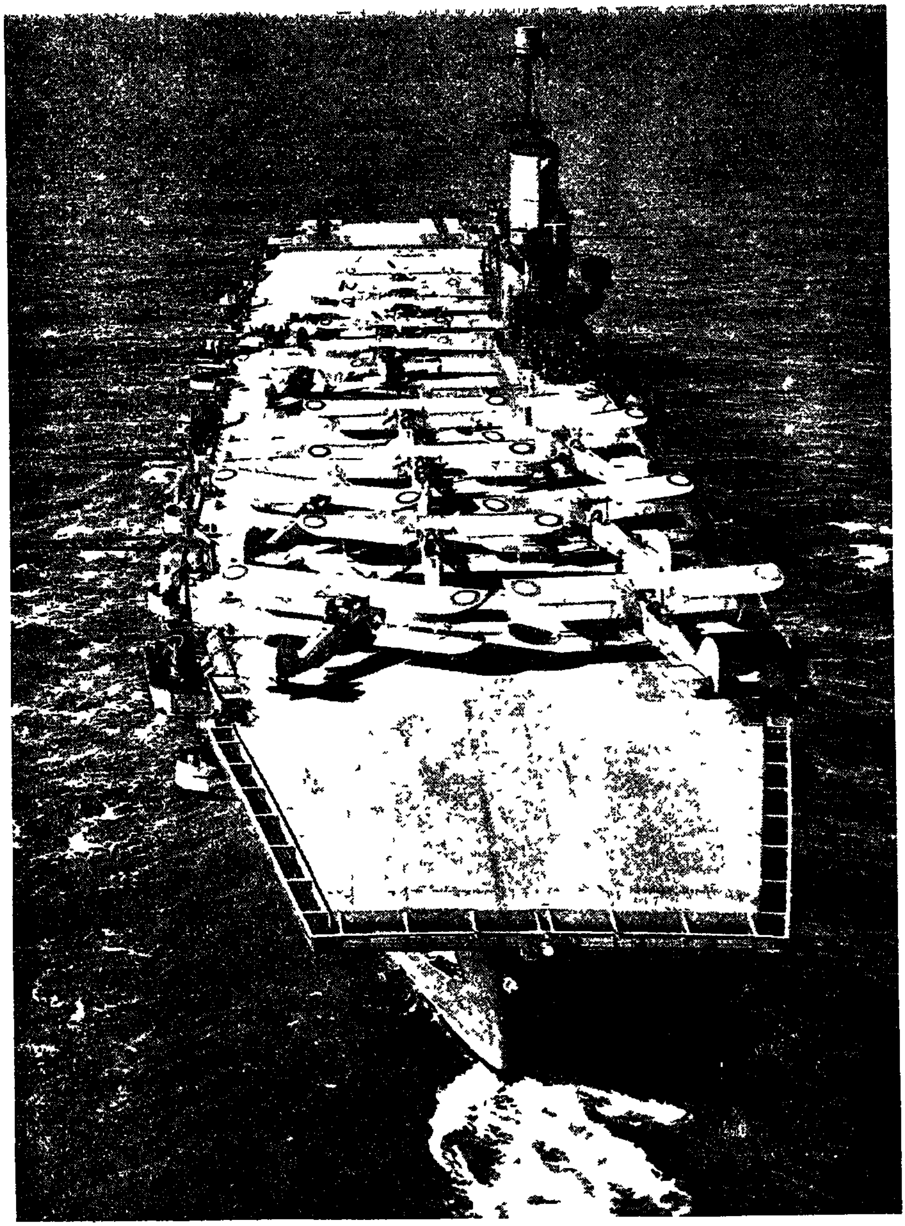
### MAINTENANCE AND REPAIR

The maintenance and repair of the aircraft of the Fleet Air Arm are carried out by men with graded degrees of mechanical skill. These belong to three other branches of the Navy—the Air Artificer Branch, the Air Fitter Branch, and the Air Mechanic Branch The last-named branch is concerned with the routine



MEN WHO KEEP THE F A A MACHINES AIRWORTHY

*Fitters inspecting the engine of a Hawker "Osprey" while a rigger works on a landing wheel They belong to the Air Fitter and Air Rigger Branches of the Navy*



H M S "ARK ROYAL," CELEBRATED BRITISH AIRCRAFT CARRIER

*This aerial view of the "Ark Royal" shows the flight deck with aeroplanes marshalled for the take off Long after the Germans had consigned it to the bottom of the sea, the ship took part in the search for the "Graf Spee" in South American waters*

maintenance of the aircraft, dealing specifically with engines, airframes, armaments, and electrical equipment. General maintenance and repair work is carried out by the other two branches, the Air Artificer Branch being concerned with work requiring a greater degree of mechanical knowledge and skill. Air artificers are all selected from ratings in the Air Fitter Branch The work of all these men follows very closely that done by the personnel of the R.A.F. already described in an earlier section.

Having glanced at the organization of the F.A.A. let us turn now to the machines and the ships that it uses.

### AIRCRAFT CARRIERS

By far the largest number of sea-borne aircraft are carried in aircraft carriers. Nearly all the earlier aircraft carriers were converted from warships of other types, but the later vessels were designed and laid down for their specific purpose These ships embody all the latest developments suggested by experience gained with the older aircraft carriers, and have profited from early mistakes

In essence an aircraft carrier is a series of floating hangars surmounted by an aerodrome known as the flight deck (Fig. 1). The hangars are generally arranged on two decks, with workshops adjoining them. Since considerable quantities of highly inflammable fuel have to be carried for the aircraft, special precautions against fire are necessary. These include bulkheads and fire doors that divide the ship into sections so that any part which may catch fire can be isolated immediately.

The large expanse of the flight deck makes the aircraft carrier an easy target for bombing planes. For this reason, in any action in which her aircraft are concerned, an aircraft carrier will be kept well away from the other ships taking part. Since the speed of aircraft is far higher than that of ships, this necessary precaution does not detract from the aircraft carrier's fighting power. At the same time, so long as aircraft from an aircraft carrier can attack an enemy ship, enemy aircraft from that ship can attack the aircraft carrier in return

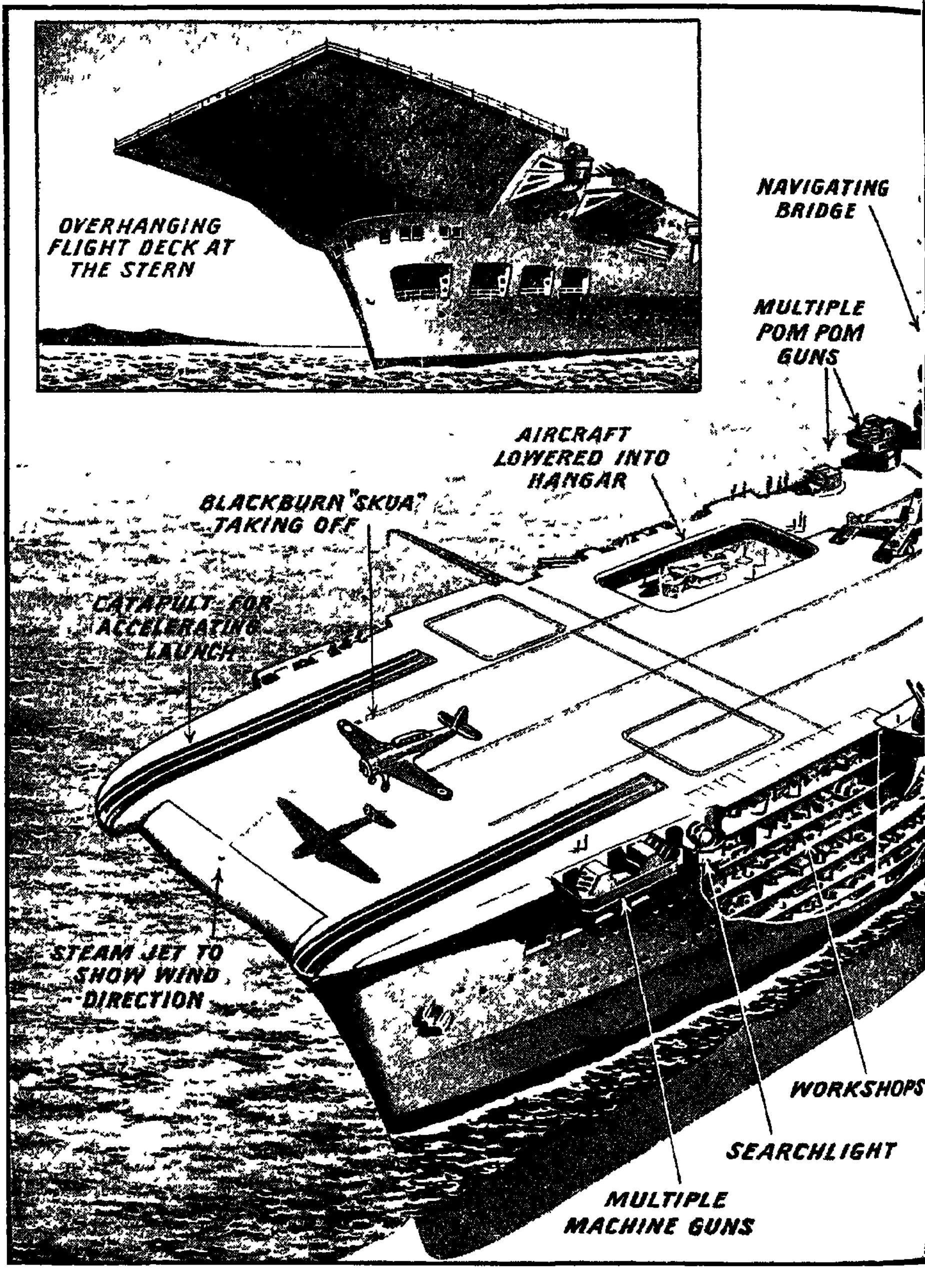
### VULNERABLE TARGETS

The flight deck of a carrier offers not only an easy target, but also a particularly vulnerable one. It is so high above water that, if it were protected with very heavy armour plating, the vessel would become top-heavy, and therefore unseaworthy. For this reason, even a small bomb may, with luck, do enough damage to the flight deck to prevent aircraft taking off from or alighting upon it, and thus make the vessel temporarily useless Aircraft carriers are therefore heavily armed with anti-aircraft guns For instance, H M.S. *Ark Royal* carries sixteen 4 5-inch guns, as well as eighteen smaller guns, among them six multiple pom-poms of the type already described.

### LOCATION OF SUPERSTRUCTURE

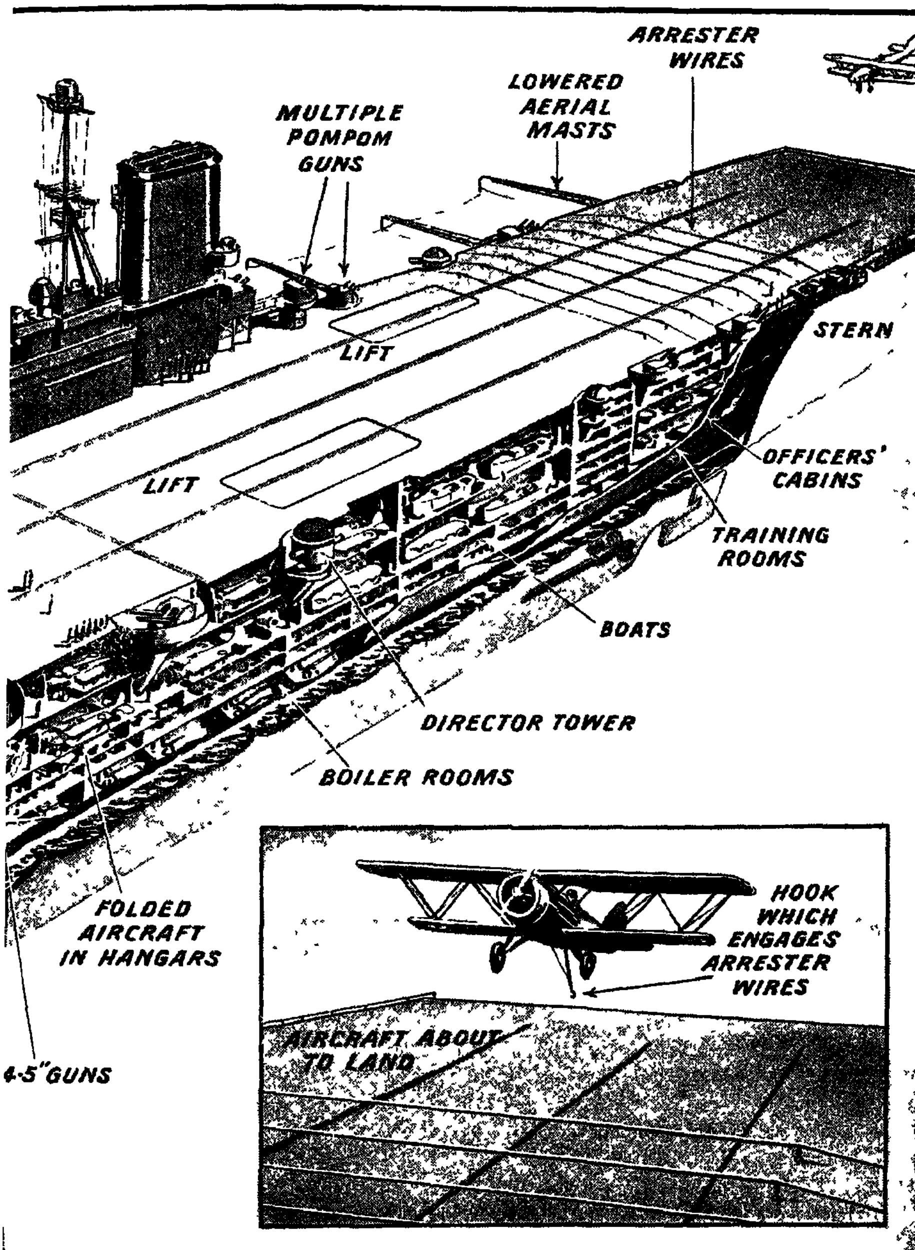
The need for a vast expanse of deck is responsible for another special feature of aircraft carriers. To provide as much space as possible for the flight deck—which may be 800 feet in length—the funnel and superstructure are placed on the starboard side of the vessel. Experiments have been made in bringing out the exhaust fumes at the side, below the flight deck, thus dispensing with a funnel altogether. But the results were not satisfactory, and the starboard side arrangement of funnel and superstructure is now universal. Moreover, the existence of this superstructure is of great help to pilots, enabling them to gauge the height of their aircraft above the flight deck when alighting.

An aircraft carrier is planned so that aircraft can be raised to the flight deck




A TRIUMPH OF NAVAL ARCHITECTURE—DETAILS

**Fig. 1.** *As many as sixty aircraft can be operated from a modern British aircraft carrier, which, despite its great size has a speed of over thirty knots High speed is essential to enable*




OF A TYPICAL BRITISH AIRCRAFT CARRIER

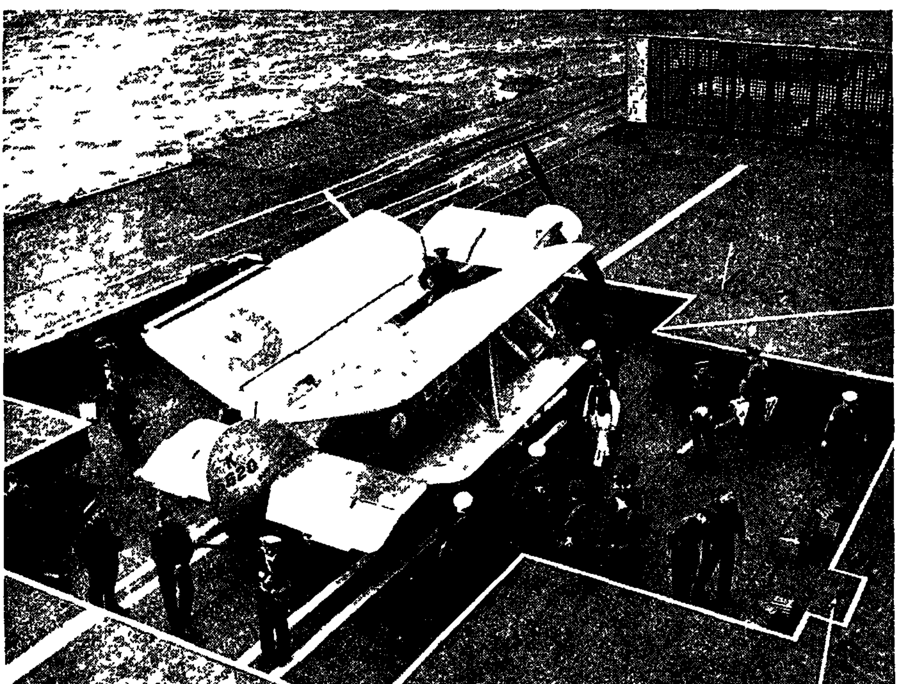
*aircraft to take off and land within the limits of the flight deck. (See Fig 3 for further details) Inset shows (above) detail of the overhanging flight deck, and (below) the arrester wires*

and made ready to take off with a minimum of delay All fuelling and maintenance are carried out in the hangars below the flight deck, where the aircraft, which are provided with folding wings, are stowed closely In this way as many as sixty aircraft are operated from modern aircraft carriers of the British Navy.

### LIFTS FOR AIRCRAFT

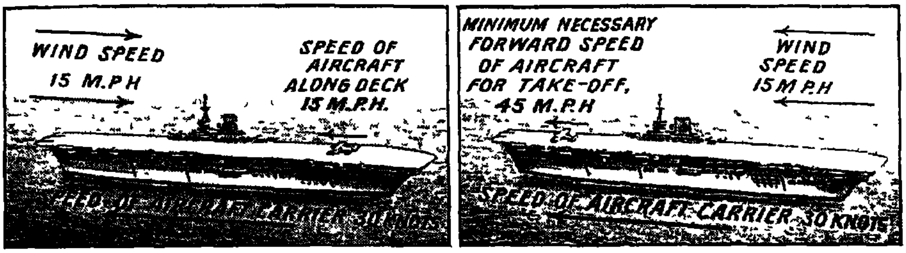
The planes are brought up from the hangars on lifts (Fig. 2), whose floors exactly fit the lift openings in the flying deck, of which, when the lift is in the "up" position, they actually form part Wind shields, which fold down flush with the deck, can be raised as and when desired, and along the sides of the ship are nets to stop aircraft falling into the sea should they run off the flight deck

The aircraft in use in the F.A.A., though of varying types and intended to serve many different purposes, are practically all aeroplanes or amphibians This may at first appear surprising, for most people imagine that seaplanes, lowered to the water by cranes, or catapulted, would be more suitable for use over the sea. But there are two objections to the use of catapults or cranes in aircraft carriers. In the first place, aeroplanes can continue to operate from the flight deck when the surface of the water is too rough for seaplanes. Secondly, aircraft can take off from a flight deck much more easily and at a considerably greater speed than from the water, and in wartime, speed in getting a number of



AIRCRAFT LEAVING THE FLIGHT DECK FOR ITS HANGAR

**Fig. 2.** *An aircraft carrier is really a collection of hangars surmounted by an aerodrome—the flight deck Aircraft are lowered or raised by means of lifts, whose floors exactly fit the openings in the flight deck, as shown The aircraft's wings fold back for stowing*




TAKING OFF FROM AN AIRCRAFT CARRIER

**Fig. 3.** *How the combination of the speed of the aircraft carrier and wind speed are of assistance to the aircraft in taking off from a small space.* (*See text below*)

aircraft into the air may be of the highest importance. Seaplanes, also, would probably prove less effective in performance than landplanes, and it would be more difficult to store and handle them aboard the aircraft carrier

### SPEED OF AIRCRAFT CARRIERS

Despite their size and apparent unwieldiness, aircraft carriers are fast ships, many of them with a speed of over thirty knots This high speed is necessary to enable aircraft to take off and land within the limits of the flight deck, and for the same reason an aircraft carrier must be able to manœuvre easily. High speed requires very powerful engines—the *Ark Royal* is driven by engines with a total of 102,000 h.p.—and manœuvrability is secured usually by fitting three independently driven propellers.

To see why this high speed and handiness in manœuvring are necessary, let us consider exactly what happens when an aeroplane takes off.

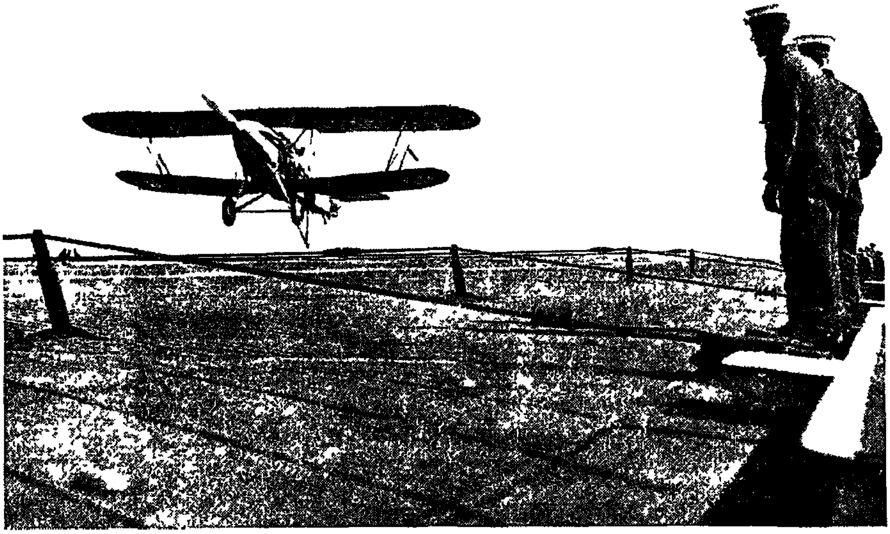
The point at which an aeroplane reaches flying speed is governed, not by its speed relative to the ground or flight deck, but by the speed with which the air passes its wings This speed—the "air" speed—is made up of the forward speed of the plane relative to the earth plus the speed of the wind blowing against it. Normally, all aircraft take off into wind, so when aeroplanes are taking off from an aircraft carrier, the ship steams directly up-wind. Unless this is done with precision the aircraft, as it becomes air borne, might be forced to the side of the flight deck To secure this precision a jet of steam issues from the bows of the flight deck, and the ship is steered so that this steam is blown backwards exactly in line with the length of the flight deck.

Fig. 3 (left) illustrates how these arrangements help the aircraft to take off from a small space. Let us suppose that the aeroplane has to reach an air speed of 60 m.p.h. before it becomes air borne

### WIND HELPS THE AIRCRAFT

The ship's speed is thirty knots, or about 35 m p h , so that this is the speed of the air past the wings of the aircraft even before it moves. If the wind is blowing towards the aircraft carrier—and therefore towards the aeroplane—at 15 m p.h. there is then a total air speed past the wings of the aeroplane of 50 m p.h. before the machine even begins to move. Consequently, when the aeroplane has achieved a speed over the flight deck of only 15 m.p.h , it becomes more than air borne. Such a speed can be attained with a very short forward run.

Similarly, with the aircraft carrier steaming into wind, the aeroplane's speed over the deck is also small when it lands Fig. 3 (right) shows the effect in similar



WIRES THAT PULL UP A LANDING AIRCRAFT

**Fig. 4.** *The camera has caught this aeroplane just before its landing wheels touch the flight deck The arrester wires which slow up the plane, and the hook beneath the machine which engages them can clearly be seen These wires are lowered when aircraft are taking off*

conditions if the ship steamed with the wind Since the aeroplane has not only lost the benefit of a tail wind, it has to go forward with an increased speed of its own of 35 m.p h. With a very strong wind, however, say of 50 m.p h., it would be possible for aircraft to land over the bows of the ship instead of the stern when the vessel was steaming slowly (say at five knots) with the wind

### ARRESTER WIRES

For this reason the latest aircraft carriers have arrester wires (Fig. 4) at the fore end of the flight deck as well as at the after end. This development is tactically important for occasions may arise when to steam into the wind might be to steam towards enemy vessels.

We have just mentioned arrester wires The purpose of these is to pull up the landing aeroplane quickly once it has touched the flight deck. A hook beneath the aircraft is lowered to engage the arrester wires, which can be raised above the deck for landings and lowered for take-offs. The wires are not fixed taut across the deck, but are slack enough to prevent a sudden jar when they are engaged by the hook beneath the aircraft They are trained against hydraulic power, and quickly bring the aircraft to a stop (Fig. 5)

Now that we know something about an aircraft carrier and the aircraft it carries, we are in a better position to appreciate the special qualifications needed by the F.A.A pilot—the man who does the job. Let us follow briefly the career of a pilot while he is being trained for deck flying Our account applies to a short-service commission pilot in peace time. Though war brings about some changes in detail, the course of training

remains practically the same as before

Before the would-be F.A.A pilot is accepted, he must pass an interviewing board, show that he has attained a certain standard of mathematical knowledge, and satisfactorily undergo a stiff medical test—which among other things, will make sure that his legs are long enough to reach the rudder bar on the standard service aircraft! When he has been accepted for the Navy, he receives the rank of midshipman or sub-lieutenant. But, to begin with, the course he will take will have nothing to do with practical flying

#### PRELIMINARY TRAINING

First of all he must learn something about naval discipline and procedure For this he is drafted to Devonport, where he will also receive his training in signalling and navigation. When, after a month or two, the time has come for him to begin to learn how to fly, he is sent not to an aircraft carrier, but to a R.A.F. flying school, where he will remain until he has completely mastered the art of ordinary flying, and has gained his wings.

Now comes the more specialized part of his training. At one of the F.A.A 's own training establishments he is taught how to take off from, and land on, a flying deck, and how to handle and manœuvre a seaplane. Henceforth all the flying he does is carried out with direct reference to his future naval work.

#### LANDING AND TAKING OFF

The handling and operating of an aeroplane from a large land aerodrome is quite different from taking off and landing on the comparatively small flight deck of an aircraft carrier, and however expert the pilot may become at the former job, he cannot proceed direct to the latter. At first, then, an area roughly equivalent to that of the flight deck is marked out on the aerodrome, and the pilot learns how to operate from this small space

When his instructors are satisfied that he is ready, the pilot is drafted to an aircraft carrier. At sea, with the aircraft carrier steaming into the wind he is given a chance to prove his worth. There is a strong breeze over the flight deck as he climbs into the training plane, accompanied by an instructor who is to make the first circuit with him. After a short

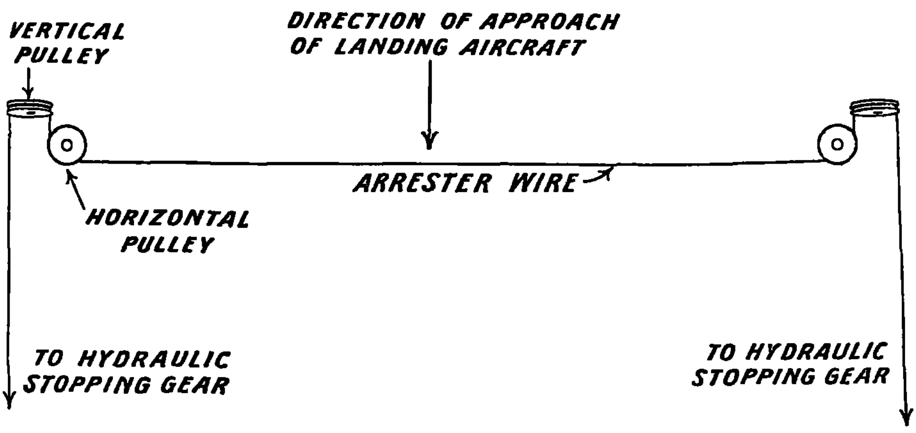
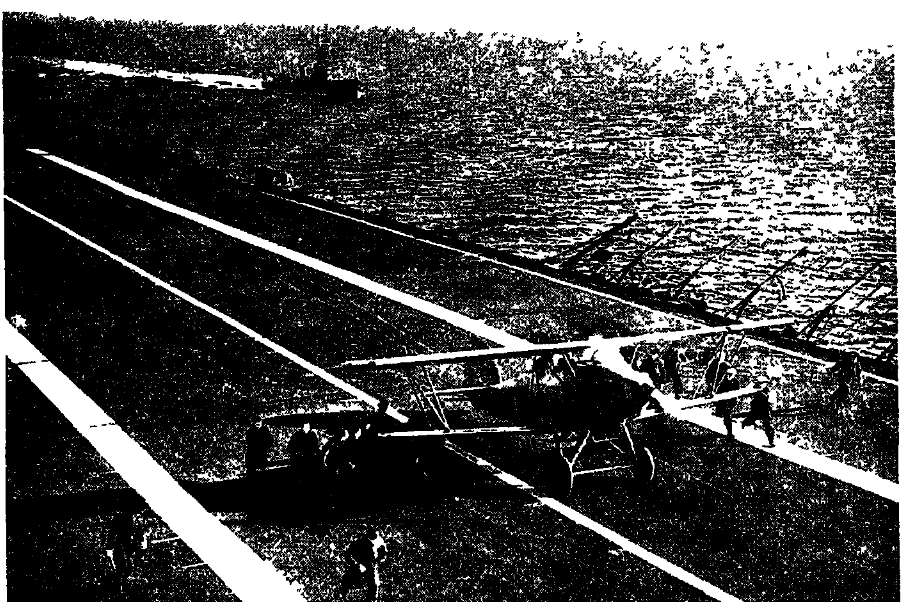



**Fig. 5.** *The above diagram shows the principle on which arrester wires operate Once the hook on the aircraft is engaged the hydraulic stopping gear quickly brings it to a halt.*

run the plane speeds over the bows of the aircraft carrier and mounts into the air. As it climbs, even the vast deck of the vessel begins to look very small against the background of the sea. The plane makes one circuit and returns for the critical part of the flight—the landing. The pilot watches carefully how the experienced instructor approaches the deck, coming in over the stern only a few feet above the vessel. The speed is just right, the plane is heading straight down the centre of the flight deck The hook engages the first arrester wire, and the aircraft is brought squarely to a standstill as men run from the sides of the deck and grasp its wings Will he ever, wonders the pilot under instruction, be able to make so clean a landing? The newly-fledged pilot makes two more practice circuits with the instructor before he is allowed to try his own skill. If he passes through these trips satisfactorily he is sent up on his own for the first time. It is a thrilling moment The take-off presents no difficulties, but the big test will come when he tries to land Before actually landing, he must make three experimental approaches He sees the instructor watching him from the flight deck, signalling with a white disc to tell him whether his approach is too high or too low for a landing (Fig. 6). His trial approaches, however, are satisfactory, and he makes the circuit once more, this time to make the real attempt He feels confident. "Lower hook," he repeats to himself, as he nears the deck, determined that the green flag, used to signal the omission of that operation, shall not be displayed

Now for it! He feels he is a little too high, but the instructor is signalling O.K. for a landing, so on he goes In the



AIRCRAFT LANDING ON H M S "COURAGEOUS"

*Landing on the confined space of an aircraft carrier's flight deck is no easy task, and F A A pilots spend months learning the art Here a rating pilot is landing on the flight deck of H M S "Courageous," the aircraft carrier torpedoed and sunk on September 17, 1939*

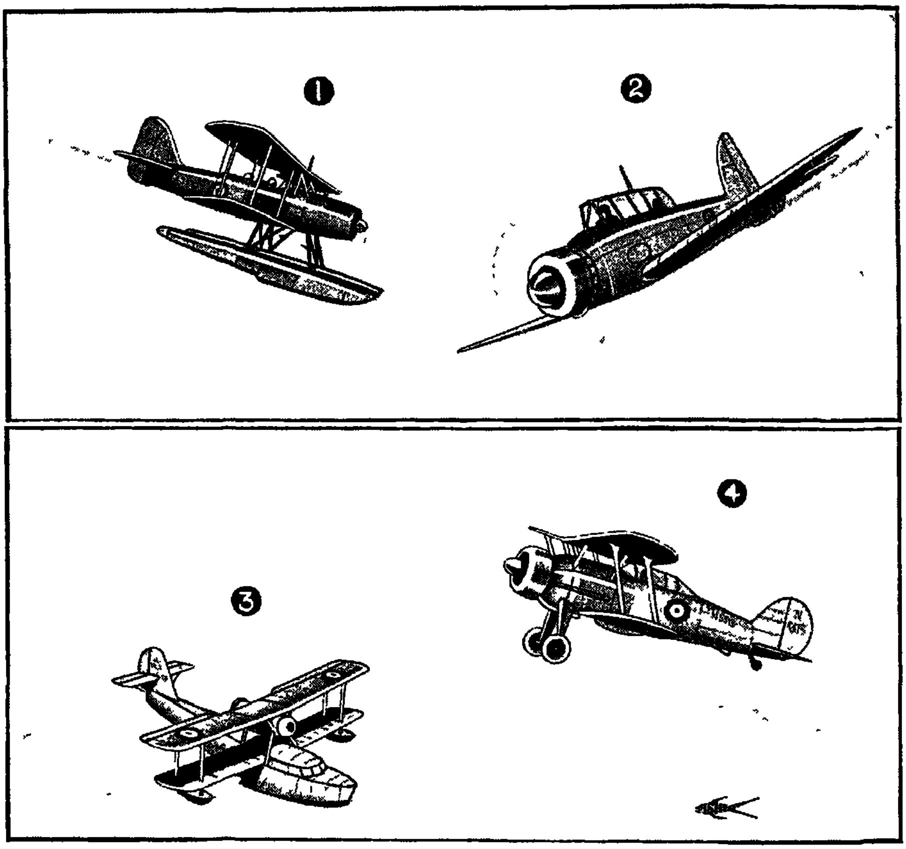
A PILOT LEARNS TO LAND AT SEA

**Fig. 6.** *Landing an aeroplane on the flight deck of an aircraft carrier requires great skill Here an instructor is signalling to a budding pilot as he brings his Blackburn "Skua" down Notice the lowered flaps (below the wings) used to check the aircraft's speed on landing*

anxiety of the moment he lets the wheels of his plane graze the deck a moment too soon The aircraft bounces slightly. Well, he hasn't done so badly after all. But just then he sees the instructor vigorously waving a flag. What's wrong? His hook has missed the last arrester wire, and he is in danger of overrunning the flight deck.

Confound that bounce, he thinks, as he pushes the throttle full open and takes off once more. This time all goes well; he makes a good landing But his training is not yet finished. After many more solo landings, he tries his skill at landing with a passenger, at landing without using the arrester wires, at landing with a torpedo attached to his aeroplane. Only then is he fully skilled in the difficult technique of deck landings.

The Fleet Air Arm does not operate only from aircraft carriers and shore stations Other warships—battleships, battle cruisers, and cruisers—carry aircraft for use from catapults. In the majority of such ships two aircraft are carried, when possible in hangars on the upper deck where they are protected




AIRCRAFT TYPES OF THE FLEET AIR ARM

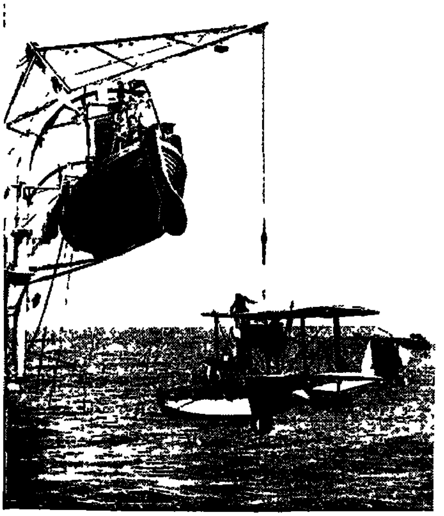
**Fig. 7.** *1, Seaplane — Fairey "Seafox" (biplane) 2, Low-wing monoplane — Blackburn "Skua" 3, Amphibian—"Walrus" 4, Biplane—Gloster "Sea Gladiator"*

from the rigours of the weather. These aircraft may be either float planes or flying boats (Fig 7). A float plane resembles an aeroplane, but has floats on its undercarriage instead of wheels. They are less seaworthy than flying boats, which can operate in water that would be too rough for float planes. Flying boats are therefore more numerous.

The flying boat mostly used by the F.A.A. is the Supermarine "Walrus," which is amphibious, that is, can land on land or water It is a biplane with both its wings above the top of the fuselage. Its single engine, mounted between the wings, drives a "pusher" airscrew—that is to say, the airscrew is mounted at the rear end of the engine As they are fitted with wheels that can be lowered, aeroplanes of this type can alight at a shore station as well as on the sea. Even more important, perhaps, their wheels enable them to come ashore from the water under their own power, and they can thus make their base on almost any coastline, should they be required to do so. These craft are shot into the air from catapults operated by cordite or compressed air, the catapults being swivelled so that the aircraft may

take off approximately into wind. Fig. 8 shows the principle on which a catapult works. The aircraft, with its airscrew turning over, is carried on a cradle mounted on a trolley (18). Attached to the front of the trolley is a cable that runs over a series of pulleys (15, 16, etc.) to a sliding crosshead (5). This crosshead is fixed to the end of a long piston (9). When an aircraft is launched, compressed air from the containers (12) forces the piston and crosshead backwards violently. The cable is thus jerked forward and pulls the trolley with it. At the end of the run a retarding cable (2) halts the trolley while the aircraft continues on its course and shoots into the air at flying speed

On returning to their ship, aircraft alight on the water, taxi to the ship's side, and are hoisted inboard by a crane. The various ways in which amphibious flying boats can operate from warships are illustrated in Fig. 9 on page 320.



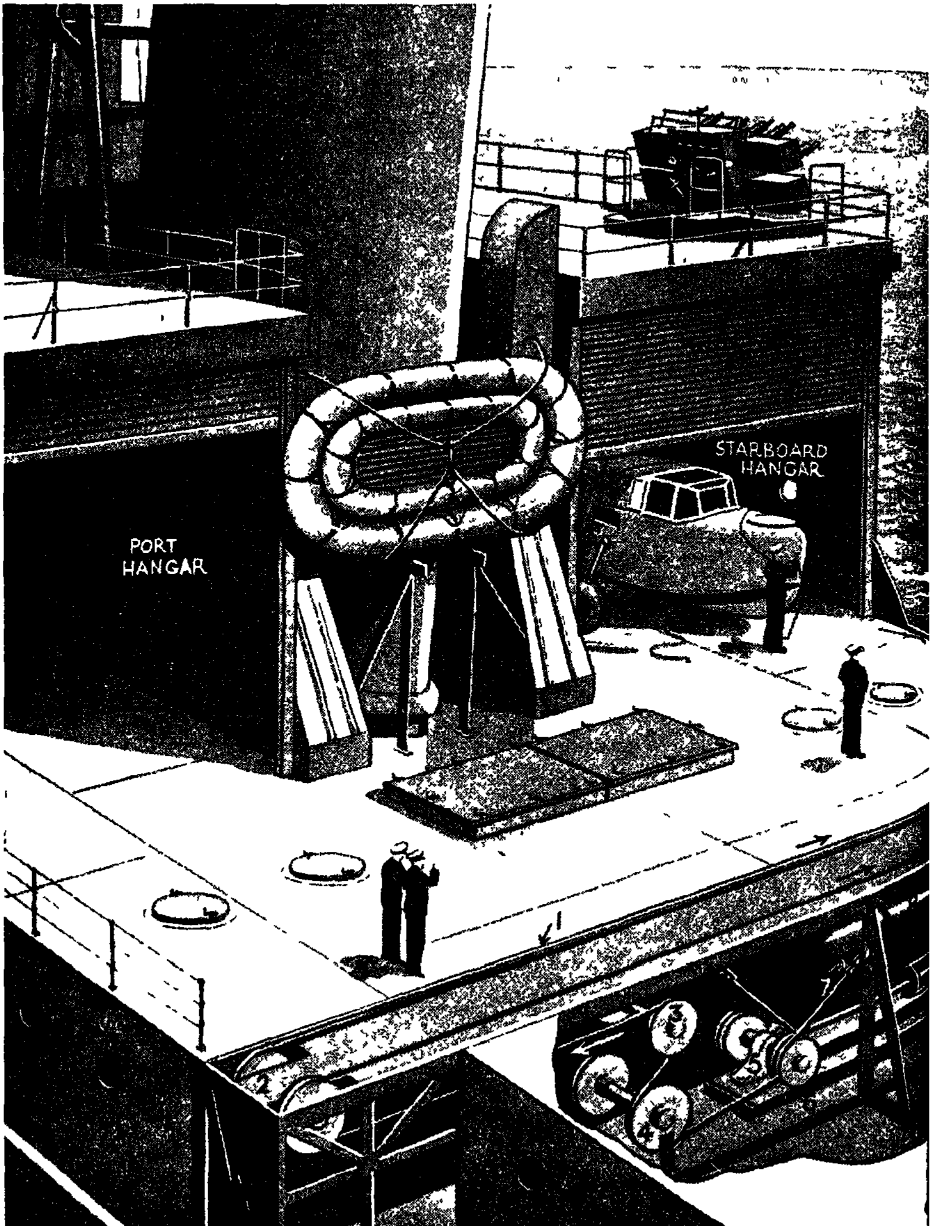
AMPHIBIAN HOISTED ABOARD
*Hoisting a Supermarine "Walrus" aboard a warship by crane All flying boats and seaplanes that are catapulted from warships are recovered from the water in this way*

The provision of aircraft in cruisers has greatly enlarged the area which can be patrolled by a single vessel. For example, let us suppose that in reasonable conditions of visibility enemy ships can be spotted if they are within fifteen miles of a cruiser This means, as Fig. 10 shows, that the cruiser herself can effectively patrol a lane thirty miles in width

### AIRCRAFT ON PATROL

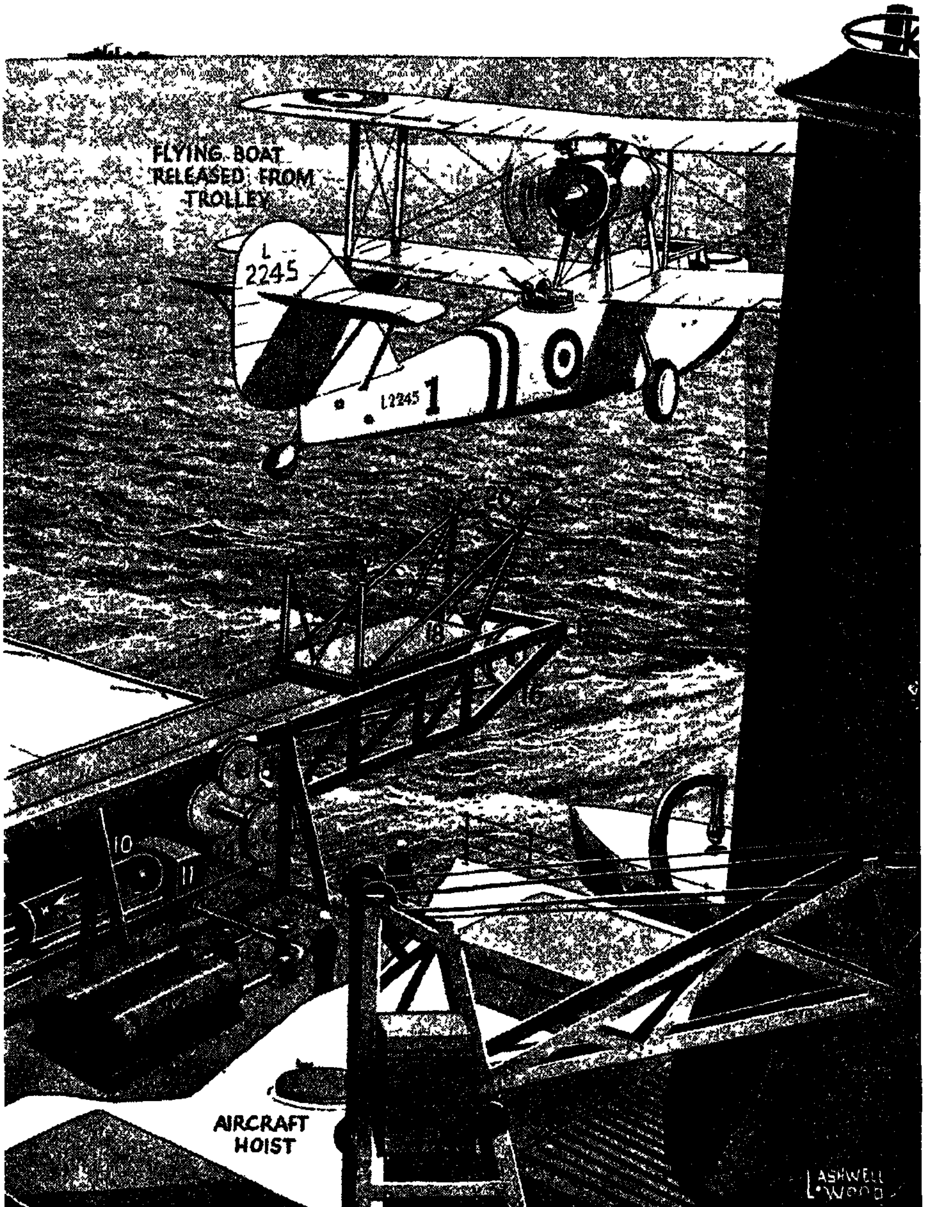
Let us assume that two aircraft are sent up from the cruiser, one to port and one to starboard. Because of their greater height, their range of vision may reasonably be expected to extend for fully thirty miles in similar weather conditions. As Fig 11 shows, the width of the lane that the cruiser and her aircraft can now patrol is increased to 150 miles, the two aircraft keeping in contact with her by radio To patrol a similar lane with surface craft five vessels steaming abreast would be needed. In reality, because aircraft travel at speeds far in excess of that at which the cruiser can proceed, they are able to fly backwards and forwards (as shown in Fig. 12), and thus while keeping up with the cruiser can patrol an area of more than five times this width, approximately 600 miles, in normal weather conditions. But it should be added that with low cloud or mist over the sea, aircraft are able to see no more than can be discerned from a ship's masthead

Reconnaissance, spotting and bombing from the air as part of the F A A's work are carried out by a general-purpose type of aircraft operated from aircraft carriers. Reconnaissance work is of paramount importance to a fleet at sea, and scouting vessels always go ahead to give details of enemy ships as soon as possible. The use of aircraft greatly increases the range over which such work can be done, just as it increases the range



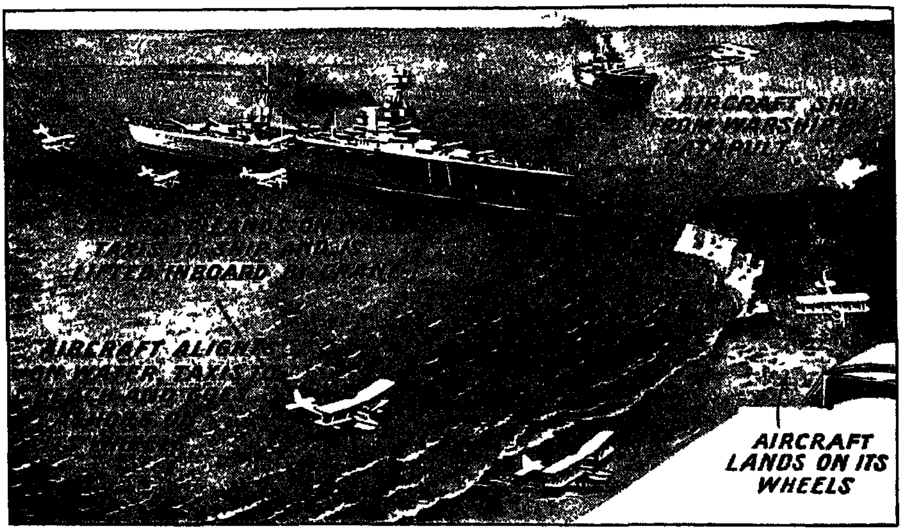

HOW A MODERN NAVAL FLYING BOAT

**Fig. 8.** *The flying boat illustrated is being launched from a cruiser of the "Southampton" class 1, Catapult trolley rails 2, 3, 4, Series of retarding pulleys and cables 5, Sliding crosshead carrying accelerating pulleys, 6, and cables 7, Cable anchorage to frame 8, Glycerine*




IS CATAPULTED FROM A BRITISH CRUISER

*chamber foı cushıon effect on pıston. 9, 10, 11, 12, 13, Compressed-aır cylındeı, valve chamber, reseı voırs and contı ol valves 14, 15, 16, Serıes of acceleı atıng pulleys and cables 17, Retractable extensıon over shıp's sıde 18, Tı ollev 19, After release hooks 20, Foı waı d release hooks*




HOW NAVAL AIRCRAFT OPERATE

**Fig. 9.** *Methods by which Fleet Air Arm aircraft take off from and return to warships Amphibians can also taxi ashore, and of course wheeled planes can land at an aerodrome*

of patrolling ships The aircraft are also able to detect submarines, in certain circumstances, even when submerged. When enemy ships or fleets are engaged, reconnaissance aircraft track them, reporting alterations in their courses, though they may be below the horizon of the aircraft carrier.

### CONVOY WORK

Occasionally the Fleet Air Arm may be called upon to assist in the convoying of merchant ships. The aerial side of this work is normally carried out by the Coastal Command of the R A F (*see* Chapter I), but in certain circumstances, the aircraft of a cruiser, for example, may co-operate with the escorting vessels.

The spotting duties of fleet aircraft are carried out on similar lines to the spotting for land guns undertaken by aircraft co-operating with the Army The spotter aircraft watch the fall of shells from a salvo and send the necessary corrections if the shells are off the target The extremely long range of big naval guns enables ships to fire at enemy vessels whose hulls are out of sight below the horizon. In these conditions the ship's range finders are of little use, and information from aircraft all-important.

But defensive duties are only one side of the work of the Fleet Air Arm. It also has its part to play in attack, with weapons of three types: bombs, torpedoes, and machine guns. Let us first consider bombs. In bombing attacks, two kinds of procedure may be employed (as explained in Chapter I): altitude bombing or dive bombing Altitude or high bombing is undertaken by general purpose aircraft, but dive bombing, as we have already seen, calls for specially designed machines known as dive bombers. For high bombing, aircraft flying level at 10,000 feet or more are employed, and bombs of the larger type are used. Bombing from great heights is less accurate than dive bombing, but the planes employed are in less danger from the anti-aircraft fire of the ship's guns, for in dive bombing they

must face the intensive barrages that can be put up by the highly efficient and deadly multiple pom-pom guns. Fig. 13 gives an idea of the apparent size of a battleship as seen from an aeroplane at different heights.

Dive bombing attacks are begun from a great height, and it is the aim of the attacking aircraft to take the enemy by surprise. The aircraft dive at a great speed at an angle approaching the vertical. The pilot aims his plane at the ship, and when within a few hundred feet of it releases one or more bombs. The speed of the aircraft carries the bombs on in a straight line to their target. For this reason a much higher degree of accuracy is to be expected than in high bombing, when the target appears very small. Immediately the bombs have been released, the aircraft pulls up into a climb away from the ship.

Torpedo attacks from the air are carried out by a special type of torpedo

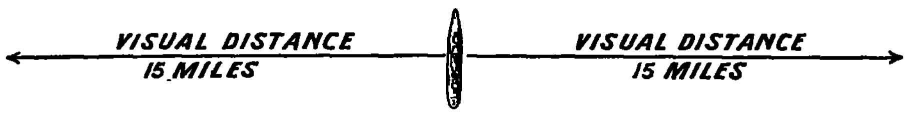



Fig. 10

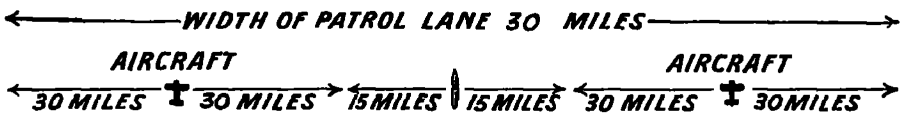



Fig. 11

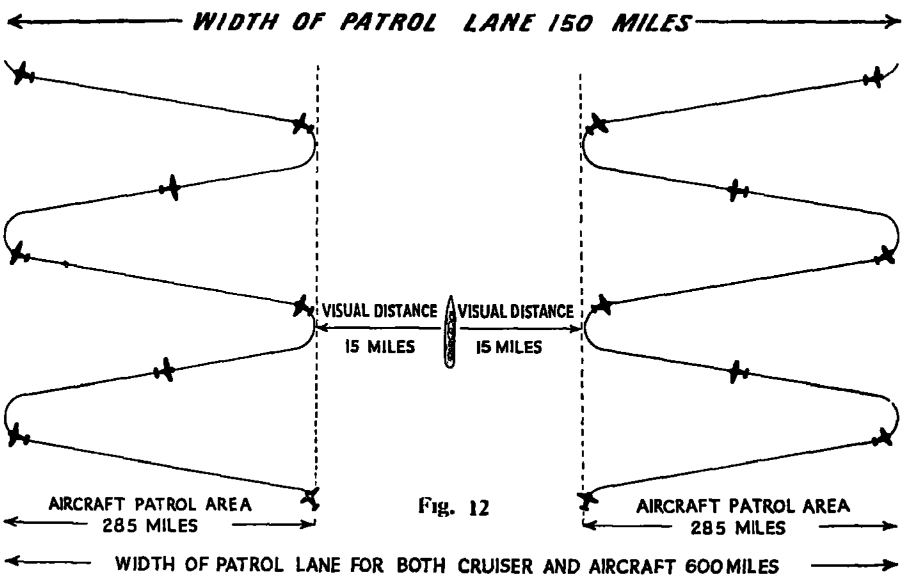
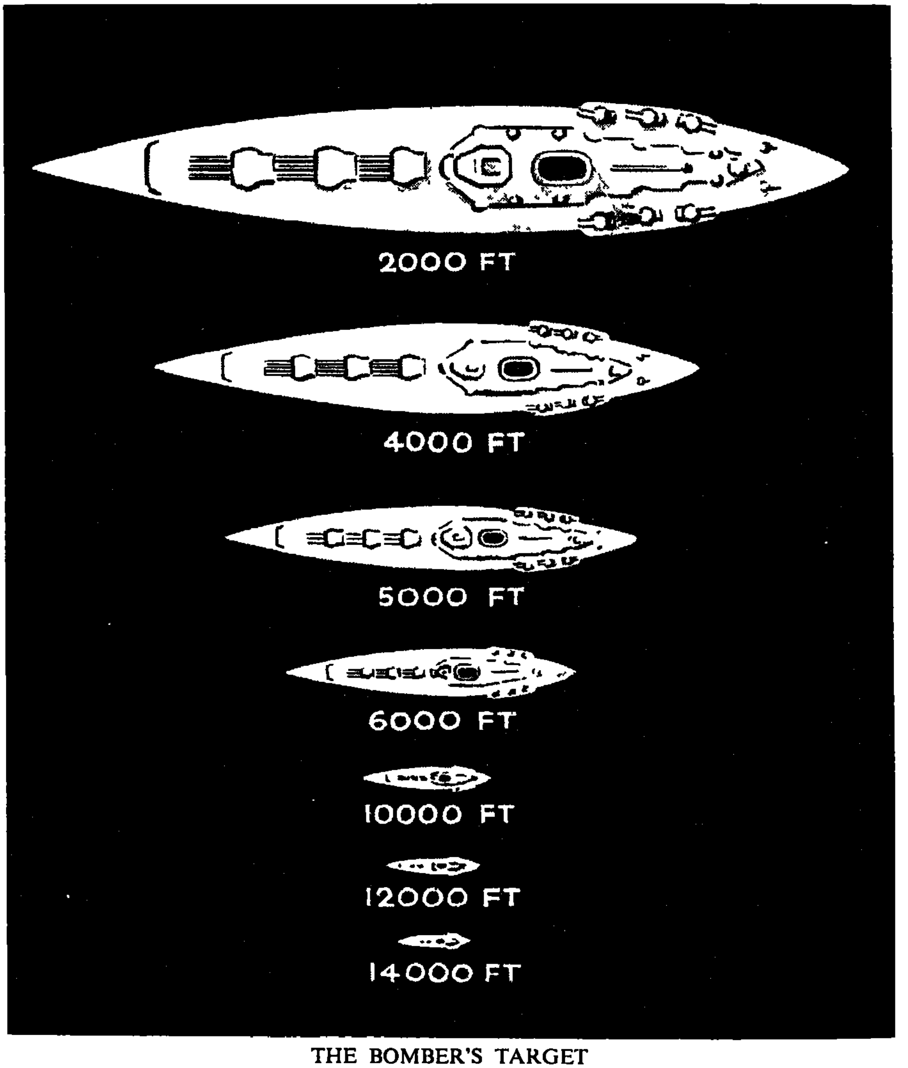



Fig. 12

*These three diagrams show how aircraft assist patrolling warships. Fig 10 shows the width of patrol lane covered by a cruiser without aircraft In Fig 11 the patrol lane has been extended by the use of two aircraft. Fig 12 shows the area further extended by aircraft flying backwards and forwards*

carrying aircraft. The torpedo, similar to that used by submarines and surface craft but of a smaller (18-inch) type, is slung beneath the fuselage of the aircraft, with the nose between the landing wheels. Approaching the ship at a great height to avoid detection, the torpedo bomber dives towards his target He drops his torpedo into the sea from a height of less than 100 feet, and within a thousand yards of the enemy ship. As the torpedo is released a trigger starts the motor that drives it.

When dropping the torpedo, his plane must be flying level, and since it is then heading at a low altitude straight




THE BOMBER'S TARGET

**Fig. 13.** *This diagram gives a clear picture of how a battleship of the "Nelson" type appears to an airman flying at various heights The difficulties of altitude bombing can be appreciated*

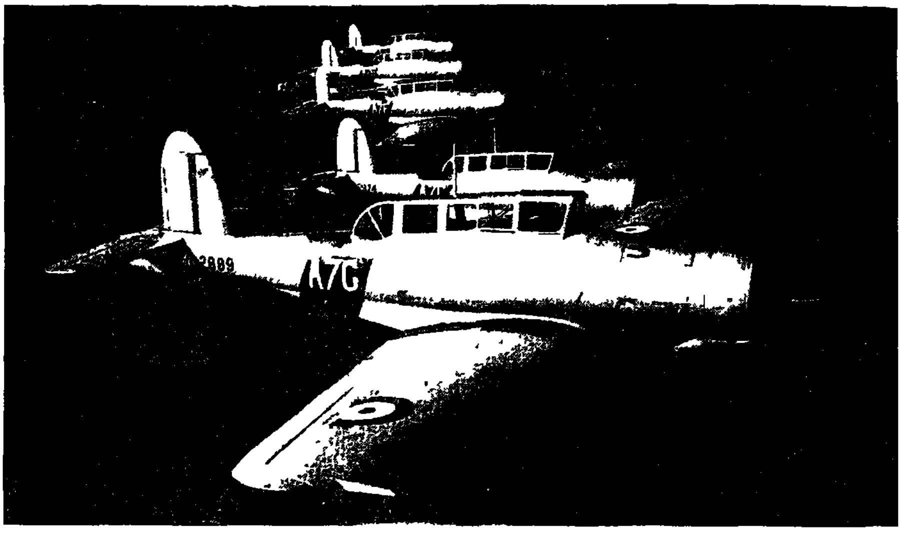
TORPEDO ATTACK FROM THE AIR

*Attacks on warships by torpedo carrying aircraft may be very damaging, as several attacks can be launched from many directions simultaneously, making it difficult for the ship to manœuvre out of danger (Top left) Torpedo carrier about to drop torpedo (Top right) Torpedo is released, at a height of about 100 feet (Below) Planes being loaded with torpedoes*

towards the ship, it is for a short period in great danger from the ship's guns. Attacks of this kind may be highly effective, for several can be delivered from many directions at the same time, so that the ship may not be able to avoid all the torpedoes by manœuvring

Fighter aircraft are extensively used by the F A A. Their duties are defensive, to prevent enemy machines of whatever type, bomber, torpedo or spotter-reconnaissance, from getting near enough to the fleet to carry out their task effectively.

The general design of aircraft for the Fleet Air Arm, like the training of its personnel, is governed by the conditions



SQUADRON OF BLACKBURN "SKUAS" IN FORMATION

**Fig. 14.** *Blackburn "Skuas" are extensively used by the Fleet Air Arm They are fitted with wing flaps and with variable pitch airscrews, factors which equip them for dive bombing*

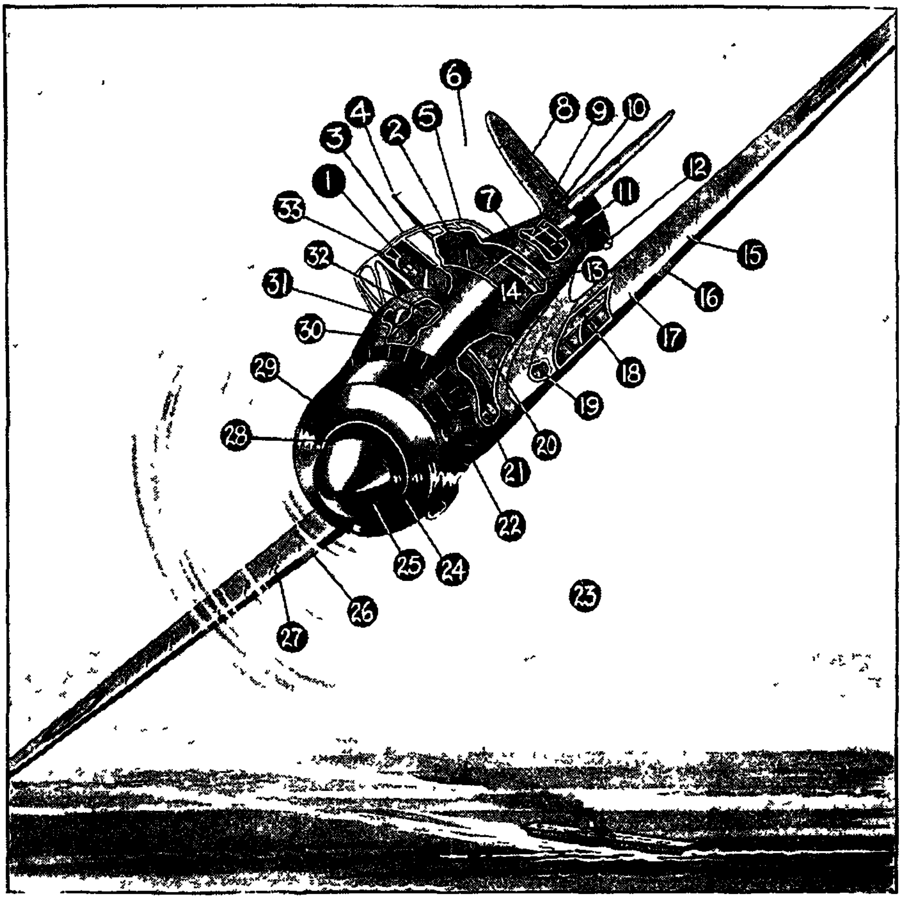
under which it works. Flying speed is as valuable in naval aircraft as in other fighting types, but it cannot be obtained by sacrificing slow landing speed, for all fleet aircraft which work from aircraft carriers must be able to take off and land with comparatively short runs. That is why the majority of the aircraft used are biplanes. Monoplanes of high speed cannot so easily operate from a restricted space. New designs are steadily being produced, however, and monoplanes are now being employed by the Fleet Air Arm in increasing numbers These new monoplanes have watertight fuselages to keep them afloat for a time should they come down in water. Earlier types of naval aircraft were provided with inflatable rubber dinghies for use in similar emergencies and conditions.

## BLACKBURN "SKUA" MONOPLANE

One of these new monoplanes is the Blackburn "Skua," a low-wing, dive bomber machine (Fig. 15). It is built with special flaps fitted in the wings to retard its speed at the bottom of a bombing dive. This makes for more accurate bombing, as it allows the plane to be brought nearer its objective before the bombs are released. The "Skua" also has an enclosed cockpit, and its construction is strong enough to withstand the strain to which it is subjected when pulling out of fast dives.

Another monoplane designed on similar lines to the "Skua" is the Blackburn "Roc." This is a two-seater fighter with a multi-gun power-driven turret (similar to those fitted to R.A.F. machines) behind the pilot's enclosed cockpit. It may be used as a float plane from catapults as well as being flown from the flight deck of an aircraft carrier.

We have left until last, mention of the most extraordinary machine in use in the F.A.A.—more extraordinary perhaps than any aeroplane employed by the R.A.F. This is the pilotless wireless-controlled light aircraft of the "Queen Bee" type, used for gunnery training, and in peace time for gunnery practice.




BLACKBURN "SKUA" LOW-WING DIVE BOMBER

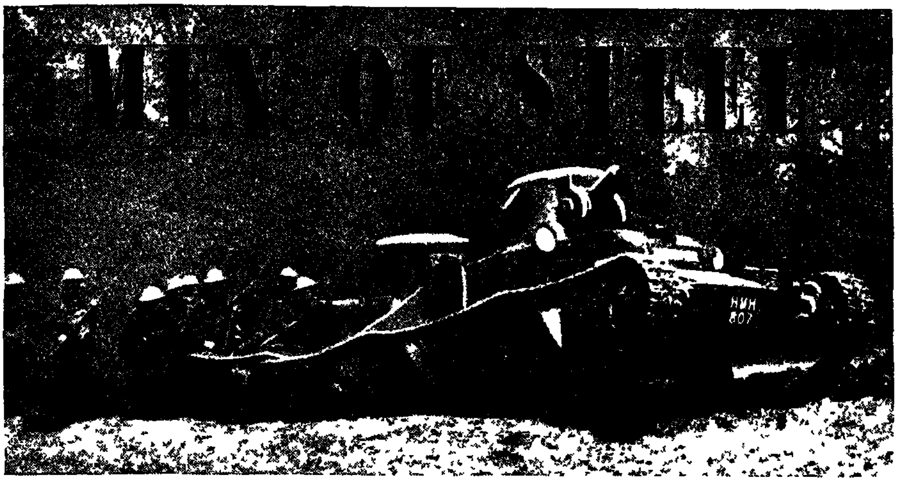
**Fig. 15.** *This all-metal F A A machine has an enclosed cockpit and is strong enough to stand up to terrific power dives. 1, Pilot 2, Rear gunner and radio operator 3, Sliding hood over pilot's cockpit 4, Aerial mast 5, Hinged gunner's cowl 6, Radio aerial 7, Radio 8, Trimming tabs. 9, Stowage space for distress signals and inflatable dinghy 10, Roof to watertight compartment 11, Watertight compartment 12, Tail wheel 13, Trailing aerial winch 14, Main fuel tanks 15, Port outer-wing gun 16, Port landing light 17, Port inner-wing gun 18, Retracted wheel in undercarriage well 19, Undercarriage operating jack 20, Fuel tank 21, Compressed-air reservoir 22, Adjustable cooling gills 23, D.H. Variable-pitch airscrew 24, Bristol "Perseus" nine-cylinder sleeve-valve 905-h p engine 25, Spinner 26, Starboard landing light 27, Starboard outer-wing gun 28, Air intake to oil cooler 29, Exhaust and collector ring 30, Oil radiator 31, Air outlet from oil radiator 32, Oil tank 33, Pilot's head rest*

These machines are launched by catapults. So effective is the wireless control that they may be made to perform all normal flying evolutions, and to alight safely on water at the conclusion of a flight. The control can operate over many miles and at great heights, and it has even been suggested that these wonderful craft may be found capable of offensive duties under war conditions.


[Medal by courtesy of Messrs Spink & Sons, London

"SOME SIGNAL ACT OF VALOUR"

*The Victoria Cross is a simple bronze ornament with a purple ribbon, awarded for "performing in the presence of the enemy some signal act of valour or devotion to the country"*



*SECTION III*

CHAPTER XI

# COMPOSITION OF THE ARMY

In the annals of the British Army are enshrined a record of victories second to none in the world. Yet it is a curious fact that prior to 1914 Great Britain had never seriously concerned herself with an army, had never seriously, that is, attempted to mobilize her man power for military purposes Before the war of 1914-18 Great Britain had relied more upon what may be described as mercenary levies than she had upon herself

The course of her history did not require that she should make vast military efforts, and probably the biggest war in which she was engaged as an unsupported nation was the South African War—in which the total casualties suffered were less than the casualties from road accidents in Great Britain during 1939.

A certain dour spirit of independence in the British nation, a determination to preserve liberty for the individual, has militated strongly against the acceptance of an obligation under which British citizens would be required, during peace time at least, to take service as soldiers in Britain's army. As a great nation, Britain has been able to gratify this passion for freedom for no other reason than that she is an island. Alike for her conquests and for her security, she has depended primarily upon her sea power, but with the growth of her Empire she has been involved time and again in land operations on the Continent and elsewhere. To a very large extent, her diplomatic alliances and her great wealth have enabled her to utilize the troops of allied powers for her military needs. Thus the

Duke of Marlborough's armies were polyglot, the British contingent representing but a small proportion of their strength. Similarly, during the life and death struggle with Napoleon, Britain did not attempt to mobilize her man power. The Duke of Wellington fought the Battle of Waterloo with an army totalling nearly 67,000 men—of these, barely 24,000 were British.

The history of the last hundred years, however, has brought about great changes. During that time Britain has consolidated the Empire which she has won and has, in consequence, been faced with the necessity of defending it against the attacks of other powers. She has, moreover, acquired the status of one of the greatest powers in the world and has inevitably assumed responsibilities either morally binding, as when she was compelled to succour Belgium in 1914 or take up the challenge of Nazi aggression in 1939: or legally binding as under treaties or the covenant of the League of Nations. These responsibilities, unfortunately, have to be implemented by the aid of aeroplanes, battleships and tanks.

### BRITAIN ADOPTS CONSCRIPTION

Even so, such was the reluctance of the British people to brand themselves as frank militarists, that not until the year 1939 could Britain be persuaded to accept conscription. In that year the appalling deterioration of the international situation brought forcibly home to the minds of the people of Great Britain a sense of their responsibilities and an appreciation of their weakness.

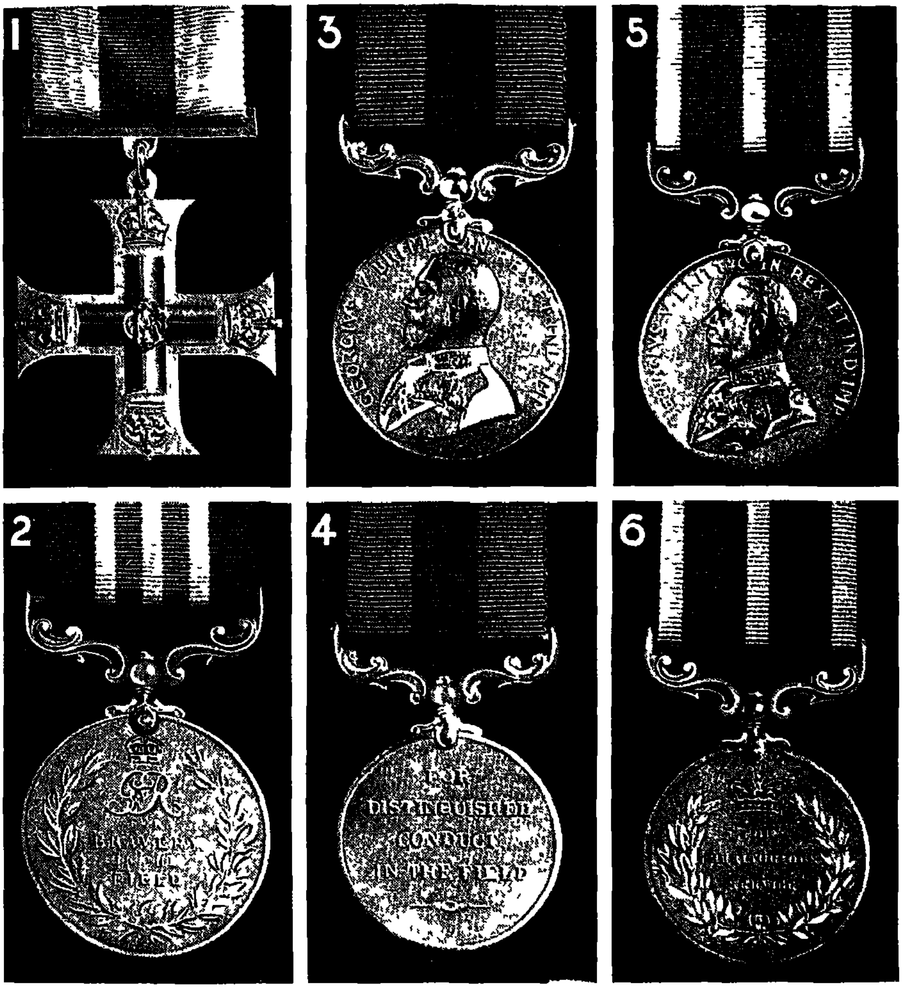
Coincident with the adoption of conscription the British Army underwent radical changes. Before that date (except for the interlude of the war of 1914-18) it had consisted of a small body of volunteers—professionals who had chosen the Army as a career. Compared with the vast armies of the great Continental powers it appeared to be insignificant. That it was not so no one doubts, and if proof be needed to justify this assurance the triumphs of the original British Expeditionary Force of 1914 are alone more than sufficient to do so.

### EXPEDITIONARY FORCES

The British Army as such, however, must not be confused with a British Expeditionary Force. Expeditionary forces have frequently been sent out by Britain in the course of her history. They were used during the Indian Mutiny and the Crimean War. Similarly, expeditionary forces were employed in the series of colonial campaigns fought during the latter part of the nineteenth century. But an expeditionary force is only a part of the British Army and its duties are limited to specific purposes. If we want properly to understand how an expeditionary force is related to the parent body, we must consider the functions of the British Army as a whole.

The two prime duties of the British Army are Home Defence and Empire Defence. So far as Home Defence is concerned, the role of the Army was chiefly of academic importance prior to the coming of the aeroplane. The first line defence of Britain was, and still is, the Navy and the invasion of Britain's shores is unlikely so long as the Navy retains undisputed command of the seas. But the aeroplane has complicated the task of defence immeasurably and has accordingly given specific point to the role of the Army in Home Defence. This subject is dealt with below.

Empire Defence also relies primarily upon the Navy. Such far-flung territories as New Zealand, South Africa and Australia are perfectly safe from invasion so long as Britain has command of the seas. None the less the Navy, in order that it should carry on at all, must be assured of well-protected bases in all parts of the




*Medals by courtesy of Messrs Spink & Sons, London*

DECORATIONS OF THE BRITISH ARMY

*An additional bar is awarded when these medals have been won more than once 1 Military Cross, obverse 2 Military Medal, reverse 3 Distinguished Conduct Medal, obverse, 4 Reverse 5 Meritorious Service Medal, obverse, 6 Reverse The M C is awarded only to warrant officers and officers of or below the rank of captain for acts of distinction or gallantry in the field It is the counterpart of the naval D F C, and has a white ribbon with a blue stripe The M M is awarded, for individual or associated acts of bravery, to N C O s and men of the Army The ribbon is blue, with red and white stripes in the centre The D.C.M is awarded only to N C O s and men of the Army, for gallantry in action, and is the counterpart of the officers' D S O (illustrated on page 208) The ribbon is red with a blue centre band The M S M is awarded for good, efficient, or meritorious service to N C O s and men of any of the three Services The Victoria Cross, which takes precedence over all these decorations and can be won by members of all three Services, is illustrated on page 326*

world, and the protection of these bases falls to the Army The function, therefore, of the Army in Empire Defence is threefold. It has to protect all land frontiers, assist the maintenance of internal security and provide garrisons for overseas bases. As explained in a former chapter, warships cannot be used for this land purpose. The work of these overseas garrisons is today increased by the possibility of air attack, and in consequence these garrisons are assisted by the Royal Air Force. Indeed, the protection of the naval base of Aden is entirely the responsibility of the Royal Air Force. This threefold task of protection, important as it is in peace time, becomes doubly so in wartime when almost any part of the Empire may be involved in hostilities As a consequence troops and armaments must be maintained in every part of the Empire to hold up the first stages of any possible attack long enough to allow reinforcements to reach the spot. The size of the forces which must be maintained in any one part of the Empire depends upon how quickly reinforcements can reach that part In isolated territories where communications are difficult, the garrison might have to hold out for weeks or even months.

### DISTRIBUTION OF FORCES

It will be realized, therefore, that the distribution of forces throughout the Empire is a problem that requires most careful thought and far-reaching organization. This problem, however, has been simplified in recent years by the fact that the various Dominions in the Empire maintain their own armies. All these armies are normally, like the British Army, professional bodies, that is, are recruited on a volunteer basis, and like the British Army the numbers in each case are small. The Dominions have today assumed the responsibility for the defence of their own territories. They raise, equip and train their own forces.

They work in the closest co-operation with Britain For example, high-rank officers and specialists in various branches of army work are frequently loaned by Britain to the Dominions. Equipment —and, to a very large extent, uniforms—are standardized The same training manuals are used and almost identical training and organization obtains in the armies of the Dominions and of the mother country. The necessity for this standardization and this close co-operation was made obvious in the war of 1914-18 when the forces of the Dominions played an important and vital part in the defence of the Empire.

### DOMINIONS IN WARTIME

Thus today the great Dominions—Australia, Canada, New Zealand and South Africa—have each their own armies. The equipment and maintenance of these armies each Dominion makes its own responsibility, but on the outbreak of war—a war in which the whole future of civilization, let alone the future of the Empire, may be at stake—the Dominions generously have placed their all at the service of the mother country. Before the end of March, 1940, nearly ninety thousand Canadian troops had arrived in Britain for service in France (Fig. 1 top) and a similar large number of Australian and New Zealand troops had reached the Middle East. Some of these can be seen in Fig. 1, centre. While the maintenance of these troops remained the responsibility of the Dominion Governments, their technical and strategic utilization was placed at the disposal of the British Army. As in the war of 1914-18, they were formed into various corps and were incorporated into one or another of the British armies operating throughout the field of hostilities.

So far as these Dominions are concerned, the outline of organization


[D and E, British Official Photographs Crown copyright

ARMIES OF THE EMPIRE

**Fig. 1.** *In September, 1939, the Dominions once again answered the call of their mother country* (A) *Men of the Canadian Army landing in England* (B) *A typical Anzac warrior.* (C) *"Aussies" pitch a tent By March, 1940, thousands of Anzacs were stationed in the Middle East* (D) *Indian Army officer inspecting pack mules* (E) *Indian driver carrying harness*

and administration used in the British Army, which follows in this chapter, applies to their troops with very few alterations. A special word is necessary about the position of India, however

The policing and the protection of this vast sub-continent, with its population of more than 350,000,000 people, has always been one of the major responsibilities of the British Army. Today the army in India is of a dual nature. It comprises in effect two armies The first is an army provided by Britain, consisting entirely of white troops and normally numbering some fifty to sixty thousand Its reserves and replacements are based in Britain. These reserves and replacements are provided for by the system introduced by Mr Cardwell when he was Minister for War, known as the "linked battalion" system.

### TROOPS FOR OVERSEAS

This system is not, of course, limited to the British Army in India, but applies to all British troops in overseas bases, from Singapore to Gibraltar. Under this system, whenever a unit is detailed for overseas service, one battalion is sent off complete with stores and equipment. It may remain abroad for as long as eighteen years. A second battalion, however, is organized in Britain, and from this second battalion replacements are sent abroad as necessary These replacements are made as sickness, death or expiration of service in the personnel of the first battalion requires

The system operates on this basis during peace time, but in wartime both battalions may be fully mobilized and it may follow in consequence that while one battalion is operating in India or the Near East the second battalion may be on active service in France. In such circumstances the battalions form two distinct units which are treated together only for simplicity of peace-time administration.

### THE INDIAN ARMY

The second army in India, the Indian Army proper, is composed of Indian troops In peace time it numbers normally approximately one hundred and fifty thousand, and it provides its own reserves. Like all British armies, it is a volunteer force, recruited on a professional basis, but while the British Army in India—that is, the army of white troops—is under the British War Office, in London, the Indian Army is under the orders of the Viceroy and the India Office Once upon a time, the native officers of the Indian Army were given the Viceroy's commission. Today, however, that army is being increasingly officered by Indians, and nowadays all Indians who reach commissioned rank are given the King's commission under which they may qualify for any officer rank, however high. Moreover, the Indian Army has now established its own military colleges—Dehra Dun is an example—and in consequence the Indianization of the army is proceeding apace.

These two armies, however, while

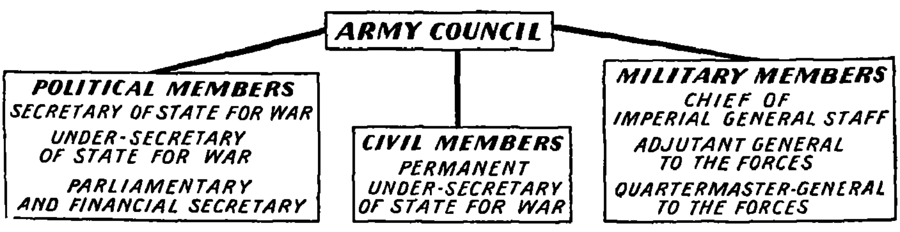



Fig. 2. *Diagram showing the constitution of the Army Council*

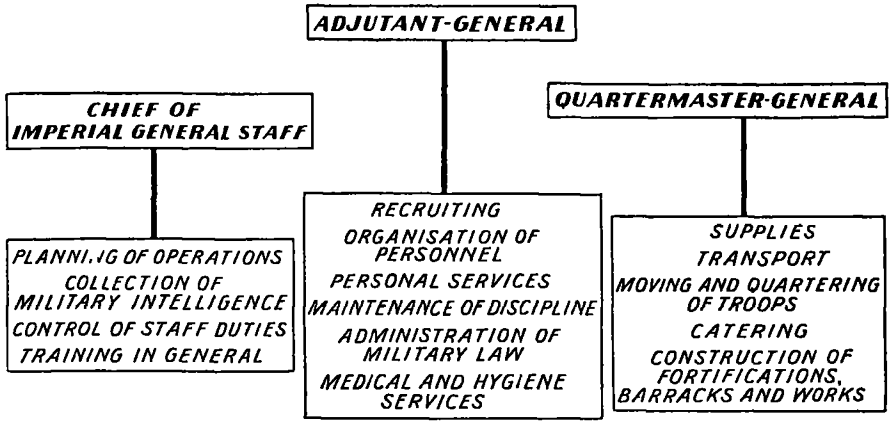



**Fig. 3.** *Diagram showing the duties of the three military members of the Army Council*

they are in India are the responsibility of the Government of India, and for administrative purposes are both under the command of a commander-in-chief at Delhi or Simla.

The Indian Army must not be confused with the private armies which are maintained by the princes ruling the various Indian States These private armies are known as Imperial Service Troops, and while affiliated to the British Indian Army are not part of it Their maintenance and their organization remain the responsibility of the States concerned

Despite the enormous responsibilities

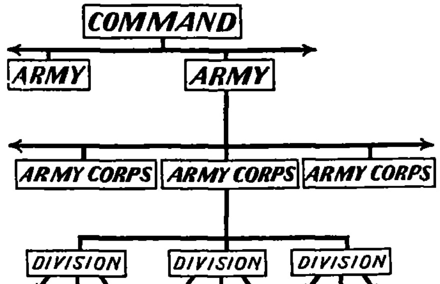



**Fig. 4.** *The make-up of a command A command has not necessarily only two armies, or an army three army corps, or an army corps three divisions. The numbers vary*

which devolve upon the Army in India for the protection of its vast territories, India has always been in the forefront of those who have offered help to the mother country in times of crisis. Even before the end of 1939 Indian troops had reached France and their numbers grew steadily (*see* bottom of Fig. 1)

### OTHER EMPIRE FORCES

The forces maintained in the rest of the Empire, in its colonial and mandated territories for example, are organized roughly in the same way as the army of India A nucleus of British—that is, white troops—are maintained (largely for training purposes) and native levies are recruited and built up around them. This is particularly true of Britain's African colonies where the native levies have reached a very high standard of efficiency. The records of the Gold Coast Regiment and the King's African Rifles during the war of 1914-18 need no extolling. In areas like Northern and Southern Rhodesia, which have a small white population, the same system applies Native troops are raised and form the bulk of the army, but there is in addition a volunteer force for the white population. These forces have always been

prominent in the defence of the Empire.

Having glanced at the duties which the British Army is called upon to fulfil and of the relations of its various parts, we can now turn our attention to the organization of the main Empire military forces, the forces of Great Britain proper.

The organization of the British Army today is as different from that existing in 1918 as the organization then was from that obtaining before the war of 1914-18. War, of course, produces rapid changes in military organization, and many of them are kept close secrets The details of army organization to be outlined in this chapter, and in those that follow, are based on the organization of the "New Army" of 1939, taking into account known modifications since the end of that year For instance, in September, 1939, after the outbreak of war, the Territorial Army was merged with the Regular Army, and for the time being ceased to have a separate existence.

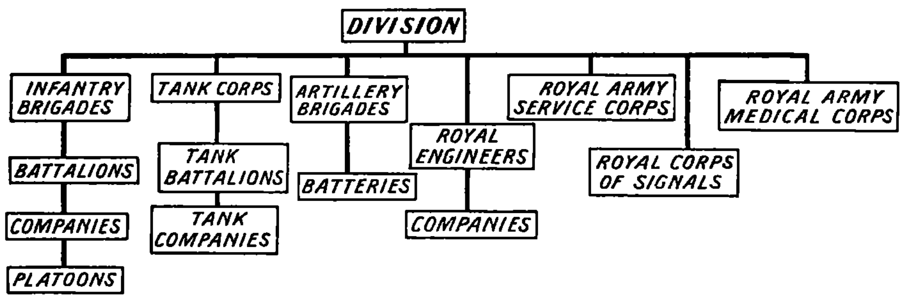



**Fig. 5** *How a division comprises a number of combatant and non-combatant units The number and type of units vary with the work to be undertaken by the division*

### THE ARMY COUNCIL

The supreme command of the Army is invested in the Army Council As in the cases of the Air Council of the R.A.F. and the Board of Admiralty of the Royal Navy, this council is composed of political, civil and military members (Fig. 2) The three political members are the Secretary of State for War, the Under-Secretary of State for War, and the Parliamentary and Financial Secretary. The civil member is the Permanent Under-Secretary of State for War.

### DUTIES OF THE MEMBERS

Of the military members, the First, Second and Third are the principal. The First Military Member is the Chief of the Imperial General Staff; the Second Military Member, the Adjutant-General to the Forces, while the Third Military Member is the Quartermaster-General to the Forces. In addition, there are the Director-General of the Territorial Army and the Director-General of Munitions Productions Since the Territorial Army was merged into the Regular Army, the work of the Director-General of the Territorial Army has largely fallen into abeyance. The Department of the Director-General of Munitions Production has been transferred to the Ministry of Supply.

The duties of the three military members (Fig. 3) are as follows· the Chief of the Imperial General Staff is concerned with the planning of operations, the collection of military intelligence, the control of staff duties, and training in general. The Adjutant-General is responsible for recruiting and for the organization of the personnel of the military forces; for personal services,

maintenance of discipline, and the administration of military law; and for medical and hygiene services. The Quartermaster-General deals with supplies, transport, the moving and quartering of troops, catering, and the construction of fortifications, barracks and works

For purposes of decentralization, the Army—whether at home or abroad—is divided into commands (Fig. 4), each under a General Officer Commanding-in-Chief, whose command may be one of three kinds. He may be in command of a geographical area—such as the Aldershot Command—or one of the other command areas into which Great Britain is divided, such as the Northern Command. Secondly, he may be in command of a fortress—as, for example, Malta. Thirdly, he may be in command of troops in the field—that is, of an expeditionary force.

To assist the General Officer Commanding-in-Chief of any particular command there are General Staff and administrative staff officers, also technical and departmental advisers, and these officers, together with their assistants, form what is called General Headquarters. From there orders are sent out to the subordinate commanders commanding corps, divisions, or smaller units as the case may be

### FOUR DEPARTMENTS OF G.H.Q.

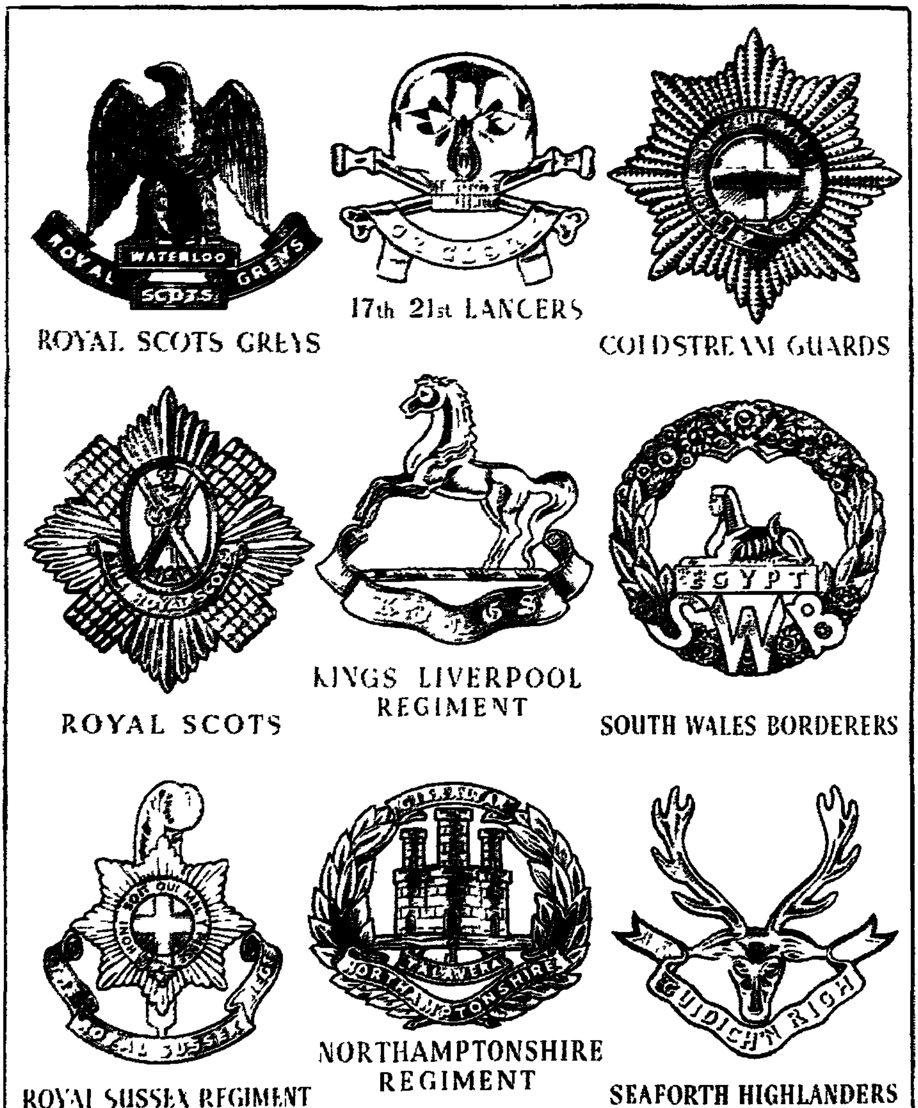
The work of General Headquarters (G.H.Q ) falls into four departments. There is the actual work of command, carried out by the G.O.C -in-C. Under him are the "G" Staff, the "A" Staff, and the "Q" Staff. The "G" Staff, or General Staff, is concerned with operations, intelligence, and all tactical and training matters. The "A" Staff, or Adjutant-General Staff, is concerned with all matters relating to personnel and discipline The "Q" Staff, or Quartermaster-General Staff, is concerned with supplies of all kinds, and also with quartering and movements.

These four branches — Command, "G," "A," and "Q" Staff—are fundamental to the organization of the British Army. They have their counterparts in every unit, from an army, through divisions and brigades, down to battalions in which "G" and "A" duties are carried out by the adjutant and "Q" work by the regimental quartermaster. The work of command passes down through the various ranks of commissioned officers to the N.C.O. in command of a few men, such as a gun section or a platoon or section of infantry. This vast organization is reproduced in each command, and for each command the Chief of Imperial General Staff, the Adjutant-General and the Quartermaster-General are ultimately responsible.

### THE DIVISION

It would be an almost impossible task even under peace-time conditions to centralize the control of an expeditionary force of, say, 500,000 men, and to handle its supplies, armaments, etc., from one point. The attempt to do so in wartime —when, for instance, a whole supply organization may be disorganized by enemy action—would be to court disaster. A smaller, more practical unit is necessary and that unit is the division, which is, therefore, taken as the basis of all Army organization. Its relation to the command and the various troops it embraces is illustrated diagrammatically in Fig. 5.

The division, the smallest formation that can operate independently in war, is a complete army in miniature, since it is made up of all types of arms and has its own supply system. It is capable of carrying on war in its own sector quite independently Should the next division to it be completely annihilated, it will not necessarily in itself be weakened or




SOME FAMOUS REGIMENTAL BADGES

*Every regiment has its own badge, often of historic tradition Royal Scots Greys' badge commemorates the capture of French Eagle at Waterloo 17th-21st Lancers uses Death's Head and motto "or Glory," in commemoration of General Wolfe The Coldstream Guards was formed in 1650 The Royal Scots is the oldest regiment in the regular army, being formed in 1633 King's Liverpool Regiment was given its prefix by George I The South Wales Borderers' badge has wreath of immortelles in commemoration of the crowning of the colours by Queen Victoria Royal Sussex Regiment's badge bears the Roussillon plume in honour of the defeat of the French Roussillon Regiment at Quebec (1759) The Northamptonshire Regiment has borne the Castle and Key since its defence of Gibraltar The Seaforth Highlanders, raised by Earls of Seaforth, carry the badge of the clan*

disorganized. In a large force, divisions are grouped together in twos or threes to form an army corps. In a still larger force two or three corps may be formed into an Army. Thus, the G.O C.-in-C. may be concerned with armies, corps, or with divisions, each of which are complete in themselves.

Normally, the strength of a division is about 12,000 officers and men, but this number is not a fixed one The actual strength of a division will depend on the work it may have to carry out and on the nature of country in which it is called upon to operate In any case, the fighting power of a division depends more upon weapons than on man power. With the mechanization of the Army, and with the increased fire power brought about by the introduction of more and more automatic weapons, there tends today to be fewer men in a division than formerly. Despite this fact, the striking power of a division is increasing. For a given strength of fire, the fewer men required the better, for extra men only mean a larger target for the enemy, greater and more complicated supply difficulties, and risk of higher number of casualties.

### COMPOSITION OF DIVISION

As has been mentioned, the composition of a division is largely dependent on the type of work it has to do. An anti-aircraft division for Home Defence will have a totally different composition from a division of an expeditionary force. Again, in a district where there are few roads and the terrain is mountainous, the transport arrangements will differ from those for a country like France. In a country covered with thick bush and

BACKBONE OF THE ARMY

*British troops "foot slogging' along a flooded road In spite of modern mechanization, the infantryman is still the backbone of the British or any other army.*

forests, fewer tanks would be employed than in open country. Nevertheless, there are two principal kinds of division, although the composition of either may vary according to needs.

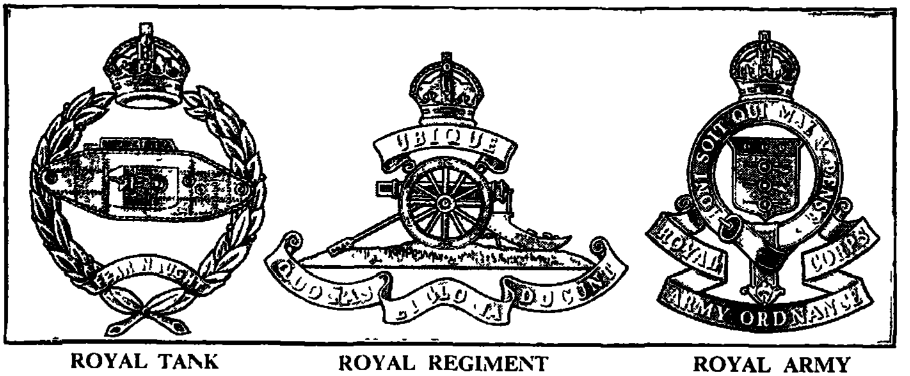
The first kind of division is based on light machine guns and is a motorized division, while the second is based on the tank and is a mechanized armoured division. The former is more mobile on roads, and the latter more so across normal open country. Both divisions will contain troops that belong to many different branches of the Army Each will include men from the Cavalry, Artillery, Engineers, Infantry, Army Service Corps, Army Medical Corps, Army Ordnance Corps, Army Veterinary Corps, Corps of Signals, Military Police, etc The term "cavalry" can be taken today to mean mechanized cavalry

Remembering, then, that all these men from many branches of the Army are gathered together in one division to form a single fighting formation, we may go on to consider the type of work the members of each branch carry out. Some branches within the division are organized in regiments—for example, cavalry regiments—while others are organized entirely in corps, like the Royal Army Service Corps. It will be found that the more recent additions to the Army are organized in corps, while those branches which have been long established are still organized in battalions or regiments, chiefly in order to maintain the traditions connected with historic names.

### IMPORTANCE OF INFANTRY

Each division includes non-combatant branches as well as combatant. Both have their own duties and both are essential to make the division an efficient fighting machine. Many non-combatant troops have to work in extremely dangerous positions, and in an emergency some of them may be called upon to fight.

Even today the infantry remains the backbone of an army. When an enemy has been driven from ground by the action of tanks or artillery, only infantry can occupy and hold it; and unless they can do this the effort of the other branches will be wasted In spite of its motorization the infantry is still a body of soldiers who do their fighting on foot



ROYAL TANK REGIMENT — ROYAL REGIMENT OF ARTILLERY — ROYAL ARMY ORDNANCE CORPS

TANK REGIMENT, ARTILLERY AND ORDNANCE CORPS BADGES

**Fig. 6.** *The Royal Tank Regiment began life in 1917 as the Tank Corps It received the title "Royal" in 1923 by order of King George V The Royal Regiment of Artillery was given its title in 1722 The R A O C was granted its prefix "Royal" in the war of 1914-18*

BRANCHES OF THE WORK OF ROYAL ENGINEERS

**Fig. 7.** *The Royal Engineers include every kind of skilled technician* (A) *A pneumatic field saw being used* (B) *Surveying* (C) *Erecting a pontoon bridge* (D) *"Sappers" learn to dismantle and repair rolling stock* (E) *A skilled etcher at work on a rotary press.*

Motorization means that the men can be moved from one position to another more quickly and can go into battle much fresher than they would after miles of "foot slogging." But the actual fighting is still done on foot for the reason that a man is more adaptable than a vehicle, and can take cover in country where machines would have to remain exposed.

The motor transport of motorized infantry consists of cars, trucks and lorries. These vehicles vary from 15-cwt trucks, capable of carrying eight men, to 5-ton lorries that can carry thirty fully equipped men together with their kit.

### INFANTRY ORGANIZATION

Just as the division is the basis of the organization of the Army as a whole, so the organization of the motorized infantry is based on the platoon In turn, the platoon is part of a company, the company part of a battalion, and the battalion part of a regiment. As mentioned earlier, however, infantry regiments are purely administrative units and never fight as such. In action, the platoon is self-contained and self-sufficient. Each platoon, which has its own truck, is divided into three sections Each platoon is armed with one anti-tank gun and three Bren guns (described in a later chapter), so that there is one Bren gun to each section of the platoon. The truck is normally used to carry these guns and other equipment while the soldiers march When rapid movement is required, and sometimes in other circumstances, the truck can be used to carry the men by taking them in relays. In this way it may help provide rapid support for another platoon. Among the many things normally carried by the truck are the armament supplies—ammunition, hand grenades and flares—the personal equipment of the men—greatcoats, groundsheets, rations and cooking apparatus. Each soldier carries his own rifle.

All the organization of infantry is planned around the platoon, including the new form of drill in which the men fall-in in three ranks instead of, as formerly, in two and then "forming fours." Although the personal weapon of the infantryman is the rifle, each man is taught to operate the Bren gun, so that casualties will not prevent it being brought into action.

In most modern battles, when infantry go into action they are preceded by tanks The Tank Corps was formed in 1917, and is nowadays known as the Royal Tank Regiment Its badge is a tank surrounded by a laurel wreath with a crown above and the motto "Fear Naught" (Fig. 6). Its members wear black berets. The types of tank in use today are designed to carry out various types of operations. All of them are offensive rather than defensive weapons

Tanks are organized in light tank companies and tank battalions. A tank brigade consists of headquarters, three mixed tank battalions, and one light tank battalion A mixed tank battalion includes medium, close support and light tanks. When going into action the light tanks act as scouts and their commanders maintain contact with the tanks in rear by radio. They are usually followed by the close-support tanks that can emit a smoke screen, the fighting tanks bringing up the rear.

Work inside a tank is somewhat like work in a submarine. It is confined, uncomfortable and arduous, not to mention dangerous. But like the submarine service, the Tank Regiment has never suffered from lack of volunteers All the men in the regiment are trained in driving, gunnery, repair work, radio operating and the general maintenance of their machines. In this way they are interchangeable and if the radio operator or driver of a tank is wounded, another

ROYAL CORPS OF SIGNALS AT WORK

**Fig. 8** *To establish and maintain communications is the work of the Royal Corps of Signals* (A) *Shows a party of signallers laying telephone wire at the double* (B) *Signallers erect a telegraph line* (C) *Field radio* (D) *A radio telephone apparatus installed in an army lorry*

member of the crew can take his place

Although the Royal Tank Regiment was formed so recently, it has units with great traditions, for a great deal of its strength was recruited from the cavalry regiments of the British Army Indeed, all cavalry regiments except the Household Cavalry, the 1st Royal Dragoons and the Royal Scots Greys were mechanized by September, 1939. There are two types of mechanized cavalry—cavalry armoured car regiments and light tank and divisional cavalry regiments.

### USE OF ARMOURED CARS

The armoured car regiments carry out work somewhat similar to that of the cavalry of former days. They can move rapidly and are useful for outflanking movements, reconnaissance, and for the protection of motor convoys The vehicles they use are not tanks in the true sense of the word because they are wheeled vehicles without caterpillar tracks. Although they are heavily armoured, their work is largely confined to the roads and they are unable to undertake heavy cross-country work like the second type of mechanized cavalry.

The light tank and divisional cavalry regiments have tanks with a crew of three, or armoured carriers with a crew of five. The former consists of a commander, a driver and a gunner for the machine gun The latter has a non-commissioned officer and four men operating an anti-tank gun and a machine gun. It is interesting to note that the commander of an armoured car squadron gives his orders by hoisting flags in much the same way as a commander at sea.

In attack and defence, the operations of infantry and tanks are supported by the Royal Artillery Their duty is to handle all guns, other than those allotted to the infantry or mounted in tanks The position of the artillery in the field is generally well behind, for the great ranges of modern guns and the necessity of indirect laying render it inadvisable to bring them close forward. As a general rule, the gunners are unable to see the target at which they are firing, the fire being controlled from observation posts or by aircraft. Sometimes it may be controlled by means of sound locators or flash spotters, without any one having actually seen the objective.

The four types of work to which the artillery has to apply its guns include field work, coastal and port defence, anti-aircraft and anti-tank, the two latter duties having been largely developed since the war of 1914-18. Artillery as a whole is divided into two main groups —field artillery and the coast defence and anti-aircraft artillery Today, all guns are mechanized, horses being maintained only for ceremonial work in peace time The field artillery includes field and mountain guns, also medium and anti-tank guns The second group has the heavier artillery and also anti-aircraft guns. It includes the searchlight regiments and battalions that work with the anti-aircraft guns. Until recently, searchlights were operated by the Royal Engineers, but their logical position is with the artillery as it is today.

Apart from anti-tank and anti-aircraft fire, the main purpose of artillery fire is to destroy enemy guns and strong positions and disorganize enemy communications. It is also used to support the infantry by means of local barrages, to break down trenches and barbed wire, to isolate areas from the enemy, and so cover troops in an attack.

### WORK OF THE "SAPPERS"

The duties of the infantry, the Tank Regiment, and the artillery are straightforward and simple to explain. The work of the Royal Engineers (Fig. 7) is more complicated and diverse. Actually, the "sappers," as the men in the Engineers

MEN WHO FEED AND SUPPLY THE ARMY—THE R A S C

**Fig. 9.** *The R A S C is really a colossal transport organization* (A) *Mechanics overhauling a lorry* (B) *Sewing canvas car covers* (C) *An electric welder* (D) *Inside the blacksmith's shop where all sorts of repairs are carried out* (E) *Loading a lorry with food.*

are called, are the craftsmen of the Army In action they live up to their motto "Ubique," meaning "Everywhere," and engage in all phases of an action from the support lines to the firing line. In addition to their engineering skill, sappers are trained fighters and can hold a trench along with infantry

### WORK OF THE R.E.s

During an advance, the Engineers deal with obstacles left by the enemy. They explode land mines, repair roads, bridges and dams and generally effect repairs or improvisations to allow the advance to continue. During a retreat the Engineers construct the obstacles and carry out the demolitions which delay the enemy pursuit. In either case they work in the dangerous area between the two forces

In addition, it is the work of the Engineers to design trench systems, build concrete fortifications, repair roads and build bridges. To them also falls the dangerous job of digging saps or tunnels under the enemy trenches or fortifications in which they plant land mines. It is on account of these saps that the "sapper" obtains his name

At one time the maintenance of communications between the various parts of an army also formed part of the duties of the Royal Engineers. Today it is of such importance, and the methods of signalling are so advanced, that communication has become the work of a separate branch of the Army—the Royal Corps of Signals (Fig. 8). Their duty is the maintenance of communications, no matter by what method. All sections of an army must be linked to a central point—which perhaps may remain in the same position for several weeks or only for a few hours. No matter where that central point is or how long it will be held, a system of communications must be established.

Line and cable communications remain the most commonly used and the most efficient. When at a distance messages sent along them can be kept secret from the enemy. Nevertheless, radio is also frequently used, especially portable radio sets that can be carried and worked by one man. When telephone lines are run out to advance posts, signallers often have to creep out and repair them while under fire. Visual signalling with signal lamps is another method used, and pigeons also continue to play their part in maintaining communications Even today, however, the dispatch rider and the "runner" are often the best and most certain method of sending messages from one point to another in difficult conditions. Whatever means are employed, the Corps of Signals is responsible for the transmission of orders from the G.O.C.-in-C. to his officers, from his officers to other officers and to the N.C.O.s

We have now given a brief description of the work of those branches of the Army which are directly concerned with fighting. They are not necessarily the most important branches, because each branch is dependent to a large extent on every other branch, and if one branch broke down the remainder of the Army would be affected. Bearing this fact in mind, let us now see something of the non-combatant branches and their work.

### TRANSPORTING SUPPLIES

The largest of the Army's non-combatant organizations is the Royal Army Service Corps (Fig. 9). It is really a huge transport organization which supplies an Army with all its needs. Its chief duty is the distribution of food and ammunition. Troops in the field must have two days' supplies within easy reach as well as emergency rations and these supplies must be maintained constantly. The R.A.S.C. is also responsible for the transport of materials like concrete, steel

WOMEN IN UNIFORM—THE W.A.T.S.

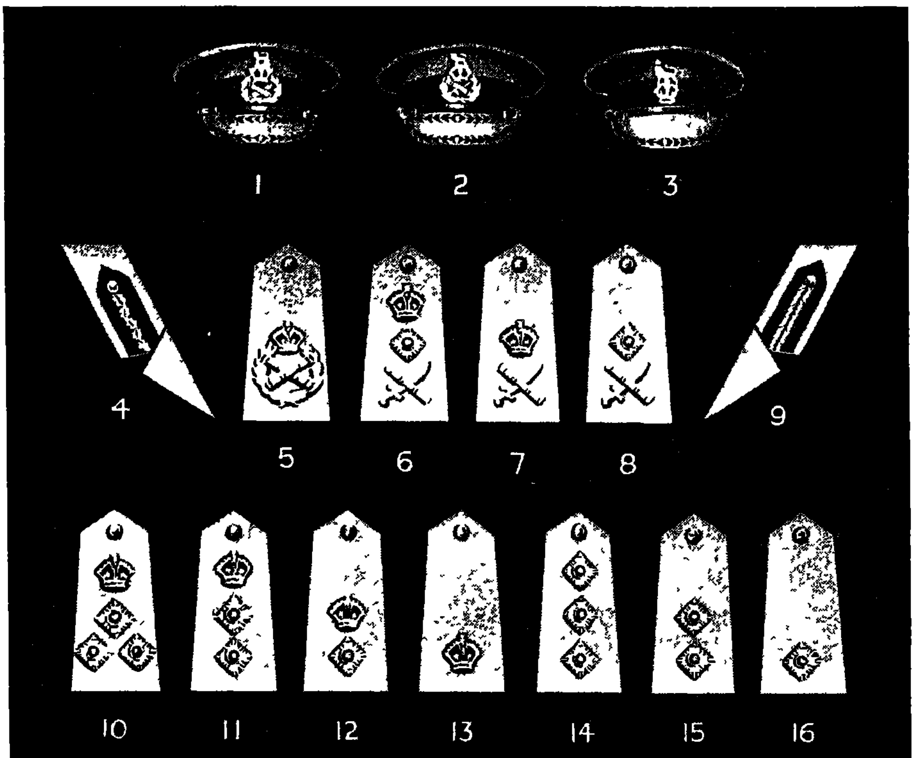
**Fig. 10.** *The Women's Auxiliary Territorial Service was formed to release men for active service* (A) *Marching with a swing* (B) *W.A.T.S. mechanic* (C) *Early morning parade,*

and a host of other things which an army in the field uses. Ammunition must also be distributed from the dumps to the infantry and to the various artillery units. The R A S C. also helps in transferring casualties from trains to ships on their way to hospitals in Britain.

### ROYAL ARMY MEDICAL CORPS

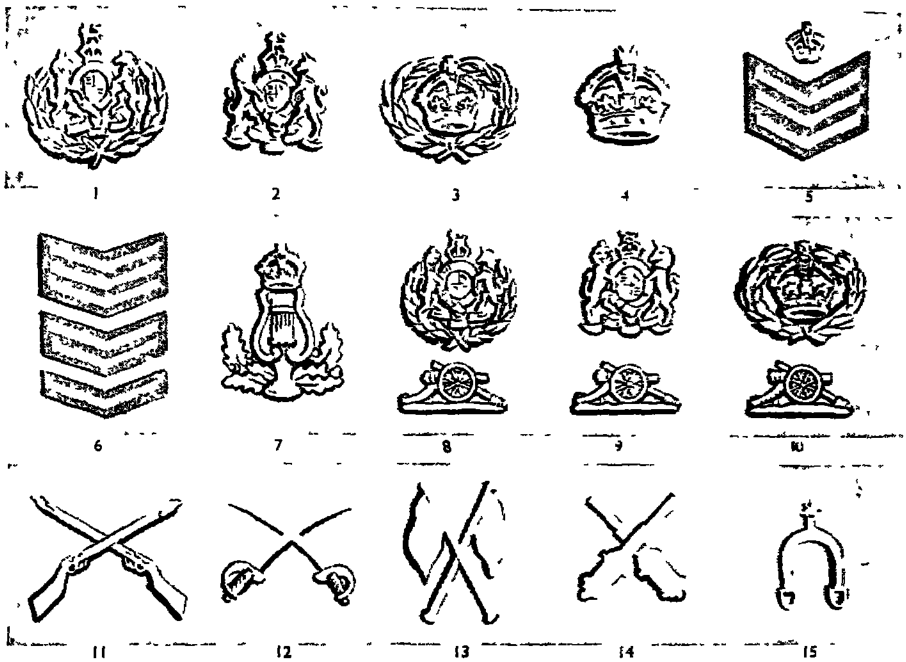
Mention of casualties brings us to the Royal Army Medical Corps, a branch of the Army whose sole duty is to take care of the wounded and look after the general health of the troops The organization of the R A.M.C. reaches from the regimental stretcher bearers who pick up the casualties on the field of battle, to the base hospitals and the hospitals in Great Britain. Even while fighting is in progress, stretcher bearers often begin to pick up the wounded men and administer first-aid while still under fire. The casualties are passed through advanced dressing stations, casualty clearing stations and hospital trains to base hospitals.

The Royal Army Ordnance Corps is primarily responsible for the Army's armaments. Actually, the work of the corps covers a very wide field. It deals with the provision, storage, handling




CAPS AND EPAULET BADGES OF ARMY OFFICERS

*1, Field Marshal 2, General 3, Staff Officer below rank of General 4, General (gorget patch on lapel) 5, Field Marshal 6, General 7, Lieutenant-General 8, Major-General 9, Staff Officer below rank of General (gorget patch on lapel) 10, Brigadier 11, Colonel. 12, Lieutenant-Colonel 13, Major 14, Captain 15, Lieutenant 16, Second Lieutenant. All badges except numbers 4 and 9 are worn on the shoulder*



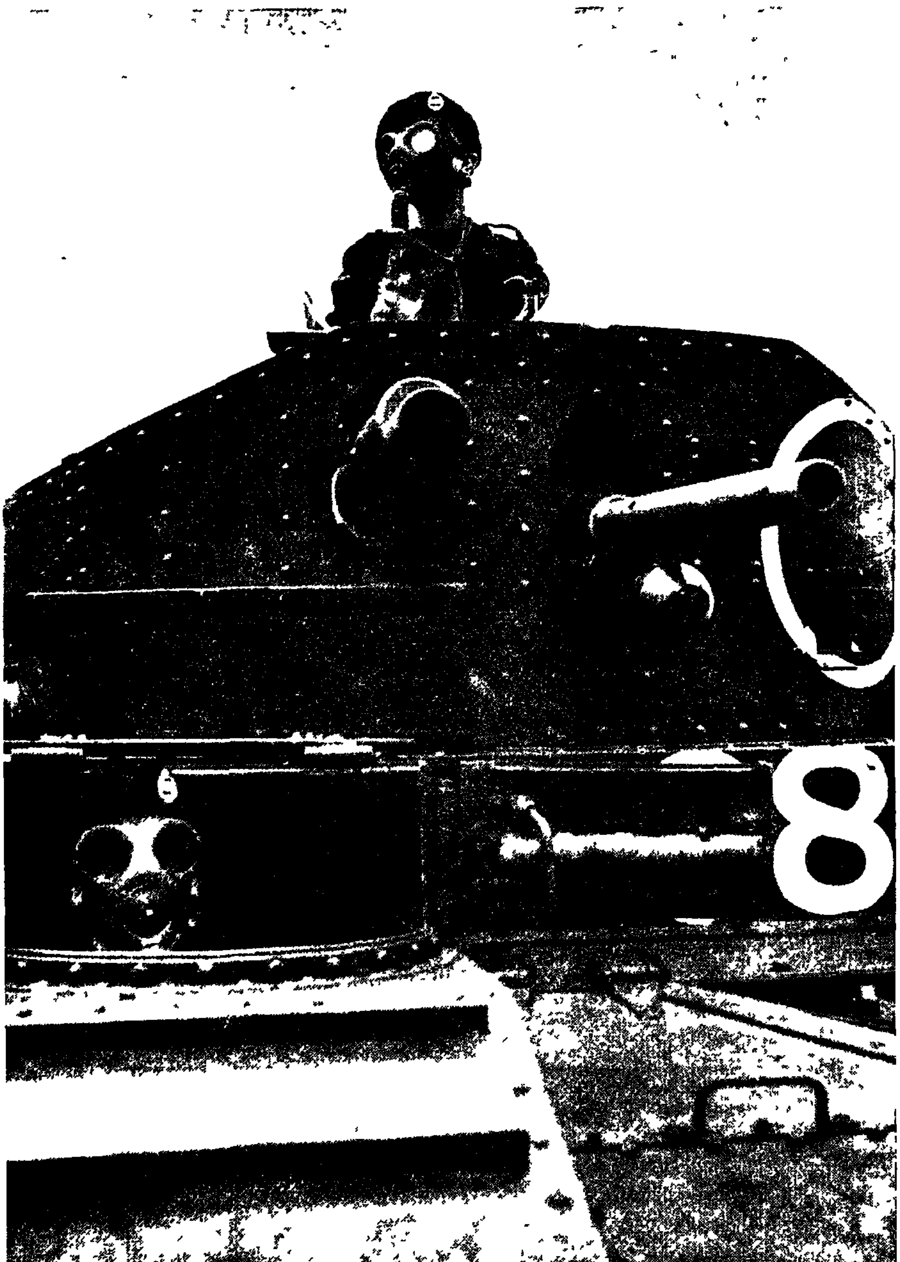

BADGES OF WARRANT OFFICERS AND N C O S

*1 Regimental Sergeant-Major, first class 2 Regimental Quartermaster-Sergeant 3 Staff Sergeant-Major, first class 4. Company Quartermaster-Sergeant or Staff Sergeant 5 Company Sergeant-Major 6 Sergeant, Corporal, Lance-Corporal 7 Bandmaster 8 Master Gunner, first class 9 Master Gunner, second class 10 Master Gunner, third class 11 Musketry Instructor 12 Physical Training Instructor 13 Assistant Signalling Instructor 14 Gunner Instructor 15 Riding Instructor*

and dispatch of stores, personal and unit equipment, armaments, ammunition, mechanical transport, clothing and other necessaries. In wartime the corps saves the Army a great deal of expense by reclaiming and repairing damaged armaments and equipment.

Other branches of the Army are the Royal Army Pay Corps, the Royal Army Veterinary Corps, the Chaplain's Department, the Army Educational Corps, and the Army Dental Corps. The Veterinary Corps is of especial interest because there are so few horses in the modern Army. In addition to looking after the horses that are employed, however, the work of the corps includes attention to animals owned by civilians in a war area. In a war of movement there will be many animals in the area covered, and every attempt must be made to prevent the spread of disease among them. When an outbreak of disease does occur, movement of animals from the area covered must be prohibited.

Finally, we must mention the Pioneer Corps and the Women's Auxiliary Territorial Service (Fig. 10). The Pioneer Corps is composed of men over military age and is organized to provide labour. Members of the W.A.T.S. are employed as drivers, clerks and in other non-combatant capacities to release men for the more active branches of the Army. They wear uniform and are subject to a modified military discipline.




TWENTIETH-CENTURY WARRIORS AND THEIR "IRON HORSE"

*This close-up of a tank crew of the Royal Tank Regiment, complete with gas masks, typifies the grim efficiency of mechanized warfare*

CHAPTER XII

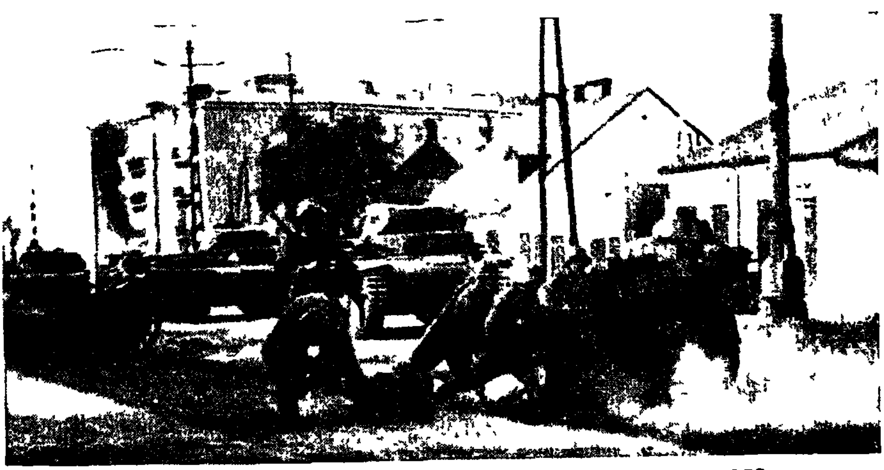
# MECHANIZATION OF THE ARMY—MODERN METHODS

THE development of the internal combustion engine has made the British Army so mobile that it appears to be fundamentally different from those older armies out of which it grew, yet in one sense there is nothing new in mechanization. British armies have always been equipped with the best weapons that the military science of their time could provide. Compared with their contemporaries they were always scientifically armed and their transport was rapid and reliable. As far as possible, man power was always assisted by machine power, and that is exactly what mechanization means.

In recent years, however, the pace of scientific progress has quickened amazingly. The old weapons have been improved, sometimes beyond all recognition, and countless new weapons have been introduced. It is with these new weapons and their uses that the following pages are concerned.

Before we describe the weapons with which modern warfare is conducted, we must consider the effect they have had upon the personnel of the Army. For there is one big difference between the mechanization of today and the mechanization of the armies of the past. Since the war of 1914-18 the process has reached a critical point. Mechanization has now become so thorough and so far-reaching that the weight of war is now borne not so much by the men as by the machines.

This revolutionary change was not primarily brought about by improvements in military science. It was caused by the recent and fundamental changes in men's habits and outlook. In everyday life we have come to depend more and more upon machinery. Our food is cooked by machinery, our clothes are



HOW POLAND WAS CRUSHED BY MECHANIZED FORCES

**Fig. 1.** *Powerful Nazi mechanized units in action in the streets of Warsaw. Despite gallant resistance the Poles were overwhelmed by the strength of the German steam-roller advance*

made by machinery, and whenever we want to go anywhere we use a motor car or a bus or a train. Military science does not so much invent as take the things normally used in peace time and adapt them for war service.

The art of warfare is mainly the art of movement. In all ages the successful commander has been he who can move his troops rapidly and concentrate them in vital areas unsuspected by the enemy. The modern dependence on motor transport has thus created the need and provided the means for the maintenance of fully mechanized fighting forces.

#### INVASION OF POLAND

The difference between a fully-mechanized army and one of the older type was strikingly demonstrated when the German forces invaded Poland in the autumn of 1939 (Fig. 1). Gallantly though they resisted, the Poles stood no chance against their fully mechanized enemy. The Polish campaign proved that the striking power of an army as a whole is revolutionized by mechanization Its advance is quicker, its mobility is more ubiquitous, and its hammer blows are knock-out punches, delivered at vital spots.

What will be the final effect of *mechanization on the* strategy of war is still open to question All the wars of the past have been based on the principle that an army is a *striking* force, dependent on movement for its effectiveness. Even prolonged trench warfare is made possible only by continuous movement of fresh supplies to the trenches. A revolutionary change *in transport methods* would therefore appear to open up entirely new possibilities in the strategy of war.

On the other hand, it must be remembered that the provision of automatic weapons seems certain to aid the defence more than the attack. This is a factor that may counterbalance that of increased mobility that attack now enjoys.

However that may be, it is evident that mechanization has profoundly changed the whole art of warfare And we must bear this cardinal fact in mind when we study in detail the various new weapons with which science has equipped the British Army of today

In the war of 1914-18 army transport depended largely on the horse. We cannot omit an unqualified tribute to that animal, for it played its onerous part in warfare magnificently. But today animal transport is forsaken and the machine has taken its place. Only the tireless internal *combustion engine can cope with modern* demands for rapid field transport.

How great that demand has become is evident from the higher proportion of machine guns now used by infantry, and from the enormous increase in automatic weapons As compared with 1914-18 the number of men in a battalion has been

TRAINING AN ARMY PACK HORSE
*In spite of mechanization, the pack horse still has its place in the British Army*

reduced, but the fire power of the battalion has risen enormously. The extra load of ammunition needed to sustain this increased fire power must be borne by the motorized transport.

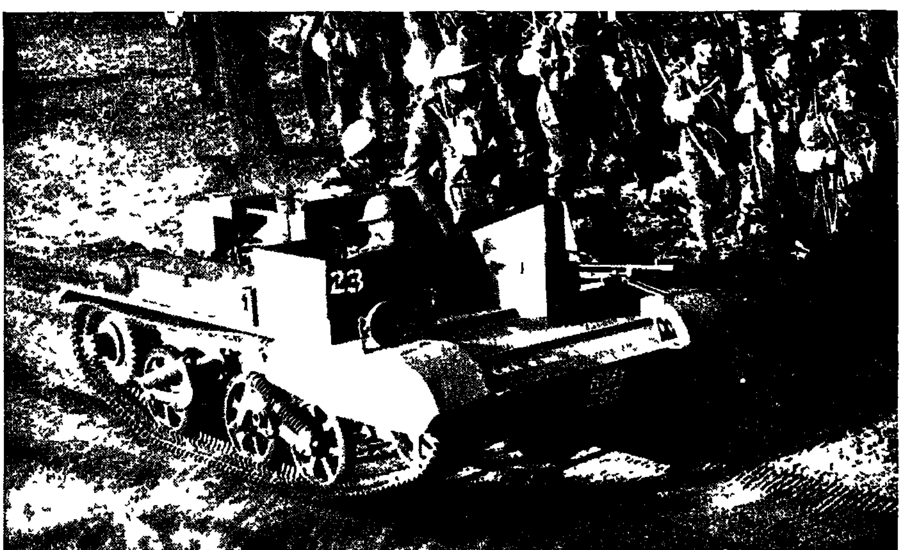
### MECHANIZATION AND THE INFANTRYMAN

The modern infantryman has, perhaps, derived greater benefit from the adoption of mechanical transport than any other branch of the Army. He has seldom to march long distances as formerly, nor, when he does march does he have to carry all the heavy equipment that was once such a burden Instead, light trucks, as mentioned in Chapter XI, carry his equipment, and, on occasions, the infantryman himself.

The infantry battalion has now become, in effect, a light machine gun battalion, for normally, each battalion carries some fifty automatic weapons. Special vehicles have been developed to carry Bren guns One gun is mounted for possible use in transit, although the vehicle is intended to be a carrier rather than a fighter. The other guns are stowed out of harm's way, to be distributed among the battalion on arrival at the scene of action.

The Bren gun carrier (Fig. 2) looks rather like a light tank, for it has steel tracks, on the continuous band principle, instead of road wheels. It is therefore easily controllable when compelled to go across country. Although its speed is not as great across a ploughed field or open countryside as along a road, it is quite a fast mover. On a really good surface it can quickly accelerate up to 40 m.p h. Even on broken surfaces its speed and manœuvrability are remarkable.

The steel tracks, one on either side, are driven round by toothed wheels or sprockets, the drive being transmitted by these wheels which are placed at the back of the vehicle. The corresponding pair

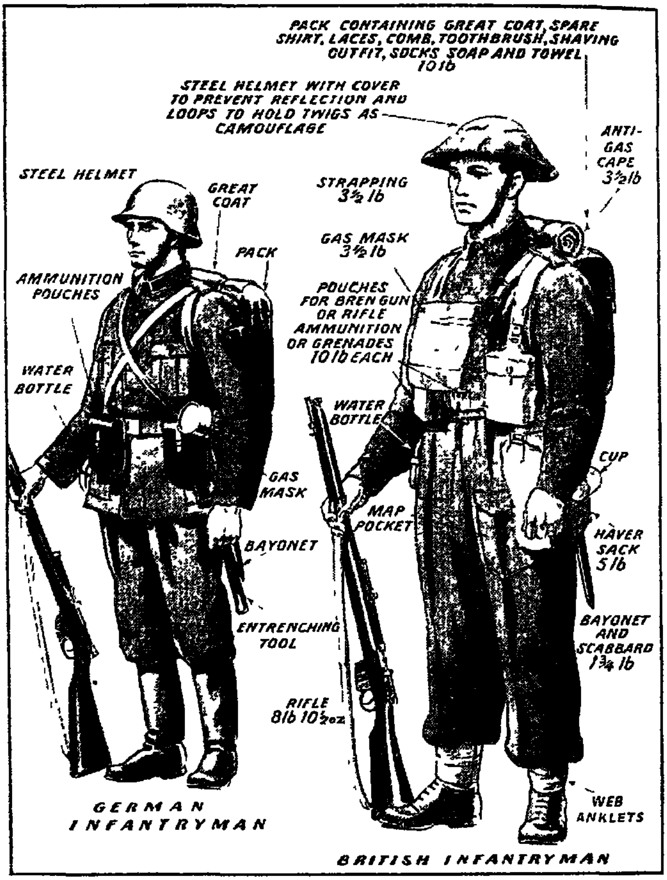


A MODERN WAR CHARIOT—THE BREN GUN CARRIER

**Fig. 2.** *Compact, adaptable and fast, the Bren gun carrier travels easily over a ploughed field or rough countryside, while on a good surface it can attain forty miles per hour. With its steel tracks and bullet-proof shields, it looks rather like a light tank*

of untoothed wheels in front, which are adjustable so as to enable them to take up slack in the steel track, are consequently known as "idlers."

The carrier has a crew of three—and there are certainly no passengers. The man in command is the gunner, and he sits in front beside the driver. Behind the gunner is the third man. Normally the crew sits in a semi-exposed position, but if it becomes necessary to take the machine into action they can be protected by pulling a lever which lowers the front seat so that the gunner and driver are brought below the level of the front bulletproof shields The third man in the rear, has room to crouch behind a similar screen in front of his own seat.




EQUIPMENT OF BRITISH AND GERMAN SOLDIER

**Fig. 3.** *The load of the British "Tommy" is nearly all above the belt, leaving his legs free and making for ease of movement. Much of his equipment is carried up the line by platoon truck*

The internal combustion engine with radiator and oil cooler is placed centrally The steering wheel, however, is in the normal position, and it is remarkable how the driver becomes acquainted with its vagaries, considering that it controls the turning of steel tracks instead of normal wheels

Powerful springs, and the application of the bogie principle to the main undercarriage, enable the structure to withstand the very heavy shocks that are inevitably experienced in use. It carries a good tool kit, as well as accessories like fire extinguishers and signalling lights, that are essential to an independent fast-moving unit.

With its protected petrol tanks, its shielded crew, and its remarkable speed, the Bren gun carrier—or Carden-Vickers vehicle, as it is sometimes called—is a thoroughly serviceable machine. It illustrates the present army practice extremely well, for it is fast and adaptable.

Speed, protection, offensive power and

adaptability to ground are the characteristics of mechanization, using that word in its ordinary sense. In the Army the term is also used with a restricted meaning, in connexion with armoured divisions. An infantry battalion using Bren guns as previously described would technically be known as "motorized," not "mechanized" But the tendency today is all towards relieving the man by the machine as far as is possible

### AN INFANTRYMAN'S EQUIPMENT

The load carried by the modern infantryman is now nearly all placed above his belt, leaving his legs free (Fig. 3) Even the bayonet, still carried on the belt, is reduced in size, and is only about half its former weight. An infantryman carries rifle, water bottle, mess tin, cardigan jacket, emergency ration, and immediate necessities, the rest of his equipment can be carried in the platoon truck, and he is thus relieved of half the weight carried by his predecessors.

Yet another advantage of mechanized transport is its wider range of speeds. It can accompany the men, when they are marching, or they can ride with it. Even at low speeds the petrol-driven truck has proved more efficient than the horse-drawn vehicle, for, on a basis of performance, petrol is lighter and easier to carry than the equivalent fodder for the horse. When all these varied factors are taken into account, it becomes apparent that the mechanization of transport has in itself effected radical administrative changes, over and above the changes it has caused in strategy and tactics.

### TRANSPORT FOR THE ARMY

To provide mechanical transport for the Army, troop-carrying companies of the Royal Army Service Corps have been established. There is one of these motor transport companies attached to every division in the field. Each company is sub-divided into four sub-divisions, each of which is capable of carrying one infantry battalion, or an equivalent load. The companies are provided with coaches or lorries, according to the nature of their work, and a troop-carrying company is quite capable of moving the division to which it is attached at least thirty or forty miles in one day. This is twice as far as a division could travel in a day before the mechanization of transport.

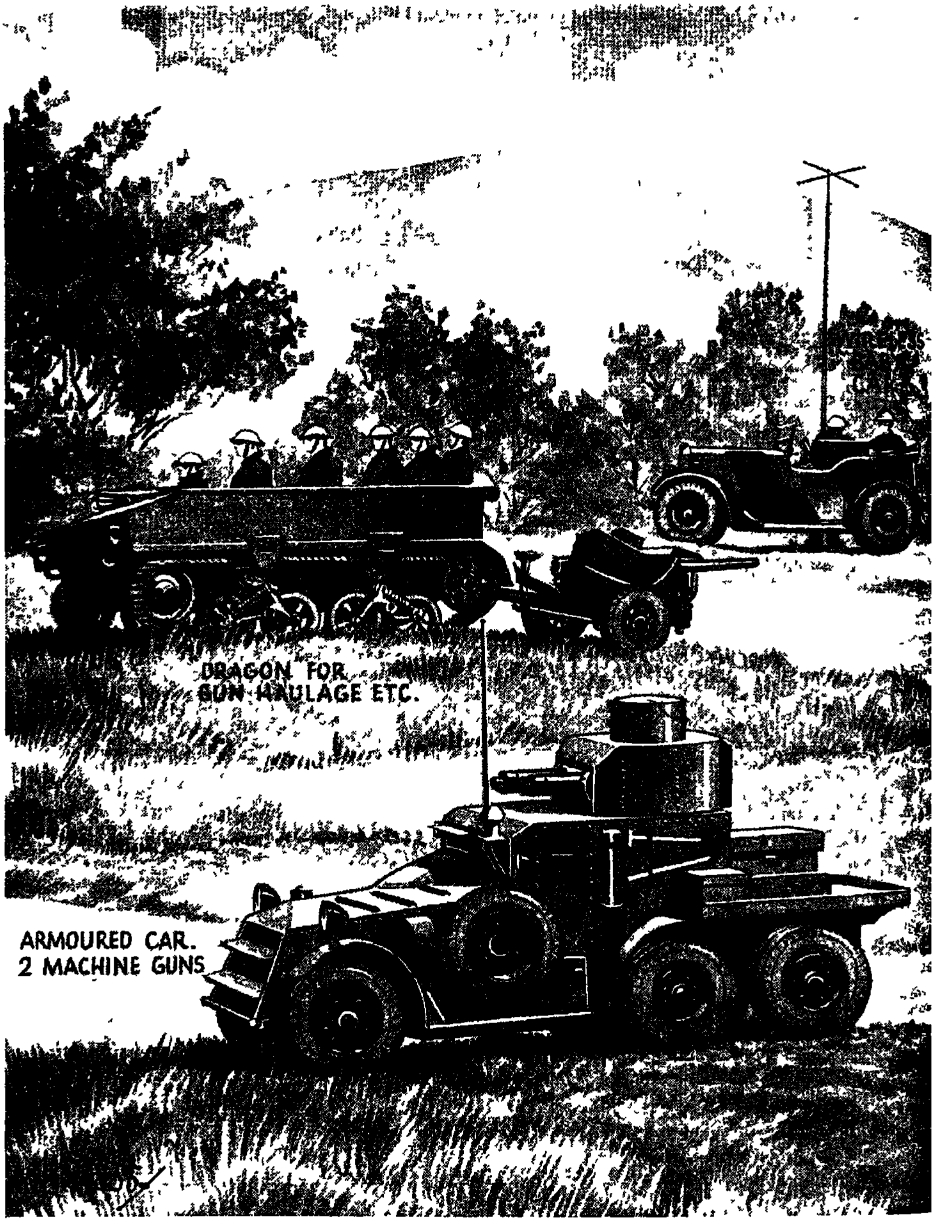
The general work of the mechanized transport is a miracle of flexibility, and it may be compared with the work of a vast civilian transport company. It carries on regular services, almost like bus services, long-distance troop movements like coach services, transports heavy loads by night, like goods services, carries miscellaneous loads for short distances, like delivery vans, makes sudden dashes with wounded men, like ambulances, and pays visits to outlying places, like private touring coaches.

### VARIED TYPES OF VEHICLES

The vehicles used are as varied as the tasks they have to undertake (Fig. 4). Almost every type of commercial vehicle has been adapted for military purposes, from light runabouts to huge multi-wheeled lorries. To make the parallel with civilian road traffic more complete, the Army uses a host of motor cycles and small cars, as well as the faster and larger cars necessary to officers whose duties entail their travelling over wide areas

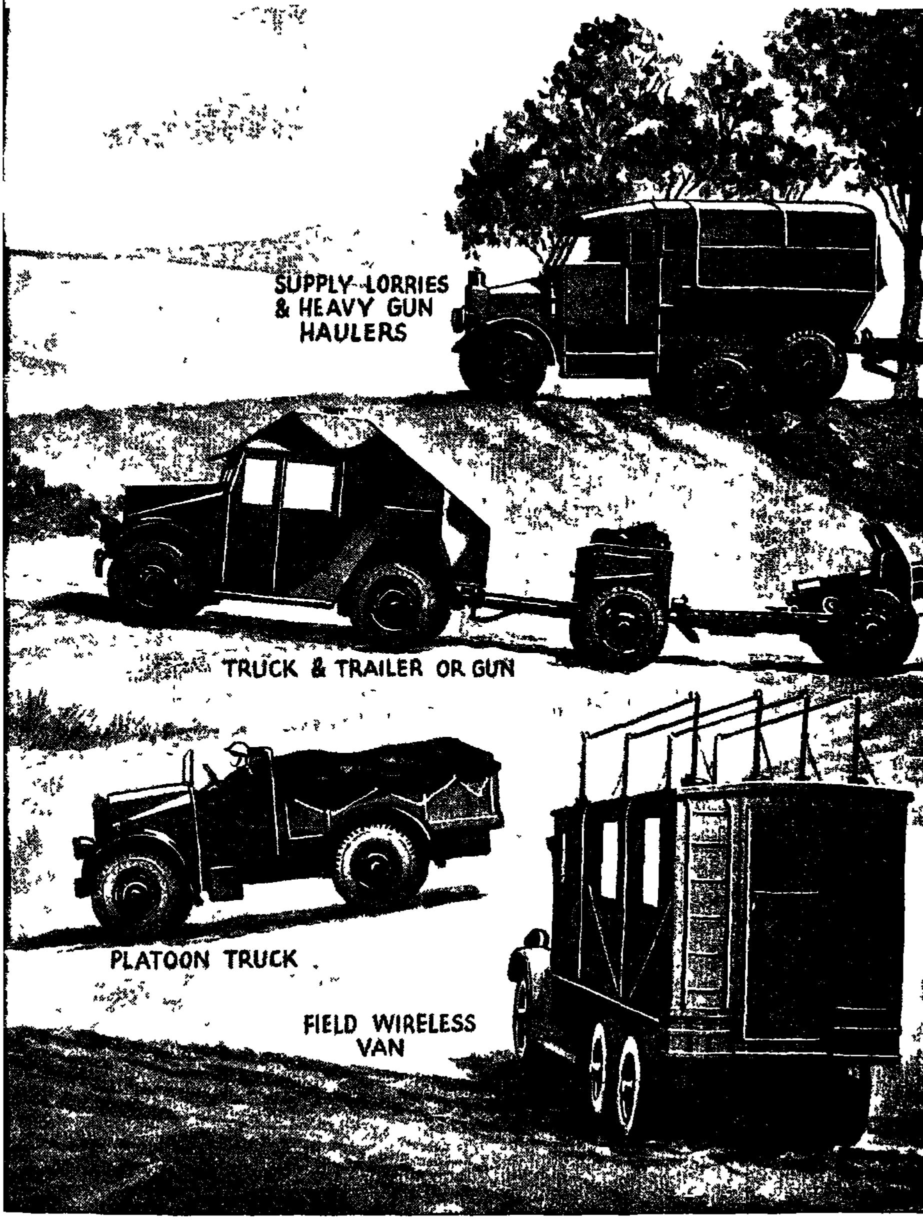
Army transport differs from civilian transport, however, in its readiness to leave the road for the fields whenever necessary. It can be realized what a great strain all this varied travel places upon the men responsible for the maintenance of the vehicles The first-class mechanic and the good driver are nowhere more appreciated than in the modern army.

Although the whole army was




BRITAIN'S MECHANIZED ARMY—VARIOUS TYPES OF VEHICLES

**Fig. 4.** *The modern infantryman goes to war amid the roar of engines and the exhaust fumes of King Petrol Nearly every variety of peace-time vehicle has been adapted for war purposes, and this illustration shows some of the most important One of the most valuable introductions, from the soldier's point of view, has been the platoon truck, which transports most*




WHICH MAKE UP THE WAR MACHINE ON WHEELS

*of his equipment, virtually halving the load he has to carry Notice that the heavy supply lorries have independent springing for their rear wheels—making it possible for them to operate in rough country Many guns are now hauled by tractor or other mechanized vehicles "Dragons" and trucks used for this purpose are also shown in this illustration*

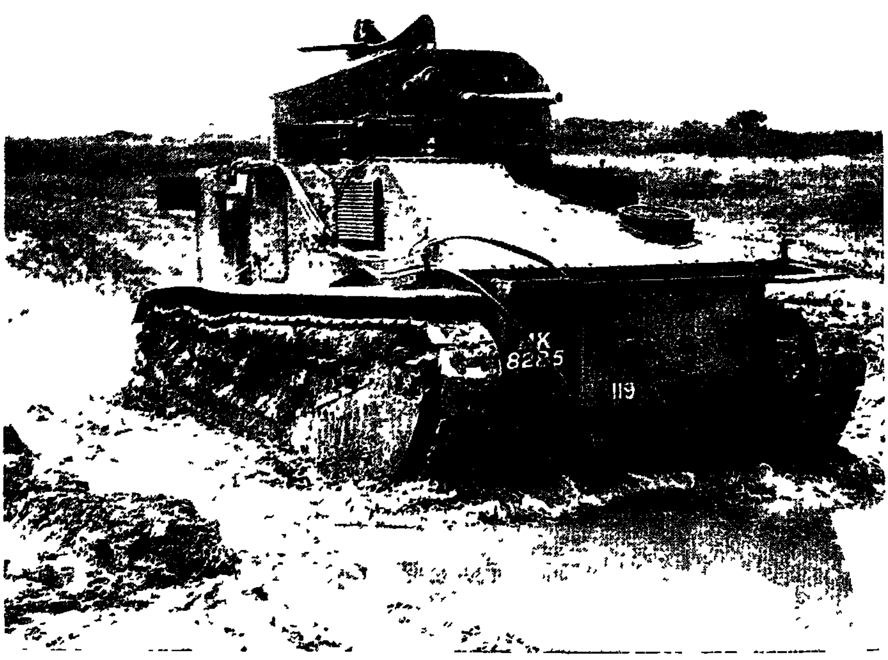
profoundly affected by the change over from horses to mechanically propelled vehicles, one branch of it was necessarily involved in more drastic changes than any other. That branch was the cavalry which has had to be completely reorganized in almost every detail.

For centuries the terms "cavalry" and "horses" had seemed almost synonymous. Now the horses have nearly all gone, but the special class of work allotted to the cavalry arm continues

Never before in the history of the Army has there been a more striking change than this Even the introduction of gunpowder did not call for such drastic remodelling as the cavalry arm has recently undergone, for the earlier firearms were relatively ineffective, whereas the mechanization of cavalry was triumphantly successful from the first.

The duties of the cavalry arm are numerous and important. Long-distance reconnaissance is one vital task arising in every war of movement, and the value of this part of the operations to the ensuing attack and defence needs no stressing It may well prove decisive.

Apart from reconnaissance duties, cavalry must operate as a swift striking force in operations against the enemy's flanks and rear. Their mobility also enables them to delay the approach of hostile forces. Another cavalry requirement, in attack, is to seize and hold advance




TANK MAKES LIGHT WORK OF HEAVY GOING

**Fig. 5.** *Modern British tanks are constructed so as to cope with the worst imaginable conditions both of terrain and counter attack Dreadnoughts like the tank illustrated above, are able to thrust their way through almost any entanglement, while firing continuously*

positions until these can be occupied by infantry. Also, the cavalry must be prepared to act as a mobile reserve, ready to pursue the enemy if he withdraws, or to defend and assist their own troops in the event of retreat.

All these duties and many others are now performed by mechanized cavalry. Large numbers of fighting vehicles of every type have been evolved and constructed. The first step in reorganization was taken when two cavalry regiments were turned into armoured car regiments. Once the change over had begun it was rapidly extended until it embraced virtually all the remaining cavalry regiments.

Some of these became divisional cavalry regiments, containing a mixed force of light tanks and armoured car reconnaissance vehicles of a lighter type. Others were converted to cavalry light tank regiments, equipped in the same way as the light tank battalions of the Royal Tank Regiment.

Before dealing further with the vehicles now used, it will be of interest to mention how tanks came into being, how they exceeded the expectations formed of them, and what were the chief of the many developments that led to the magnificent machines with which the British Army of today is now equipped.

### DEVELOPMENT OF THE TANK

The tank is an all-British invention, designed and developed secretly in this country during the war of 1914-18. The first tanks were shipped to France, and made their historic first appearance on September 15, 1916, during the latter stages of the First Battle of the Somme. They were so unexpected, so fearsome, and so lethal that their effect on the enemy was demoralizing. Armoured cars had been used during the early part of the war in 1914, but their use was limited by the fact that they could only be used on roads or reasonably good surfaces. No-man's-land, across which the attacks had to be made, had the worst surface imaginable. It was a desolation of shell holes and huge craters and was, of course, impassable ground for armoured cars

### TRACKS INSTEAD OF WHEELS

The touch of genius that enabled the tank to travel over such terrain was the provision of endless moving tracks, as used in caterpillar tractors, instead of wheels. So fitted, a tank could thrust its way almost anywhere (Fig. 5), shouldering aside ordinary obstacles, crushing down entanglements, and at the same time firing rapidly at close quarters.

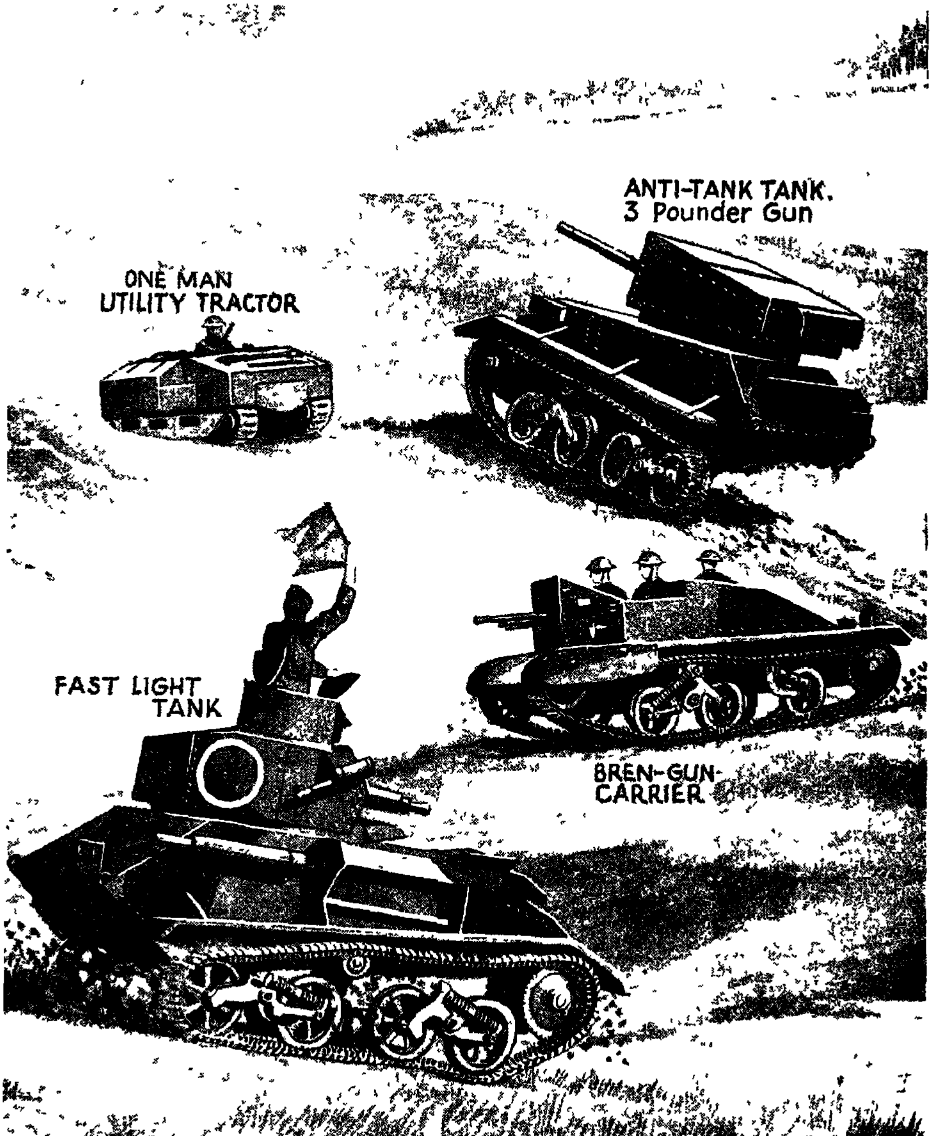
As early as October, 1914, the idea of using tanks had been considered. Experiments were conducted in great secrecy, and by January, 1916, the first tank had passed its official tests. Soon afterwards two types were in production.

The mechanism of these early tanks was essentially simple. In its original form, in 1916, a 105-h p. Daimler six-cylinder sleeve-valve engine was coupled through a clutch to a two-speed and reverse gearbox, known as the primary gear, this being under the direct control of the driver, who could thus obtain first and second speeds, or reverse, without other assistance. There were also two secondary gearboxes, each offering two speeds independent of the driver, thus the whole arrangement provided a range of four speeds. The track on either side of the tank, was capable of independent motion, forward or reverse, thus providing a means of steering.

The great secrecy that surrounded the use of the first tanks was responsible for their misleading name. When they were dispatched to France it was necessary to mislead spies who might discover the secret, so the huge cases were labelled "Tanks for Russia." Although a purposely misleading description, the name stuck, and later was adopted officially.

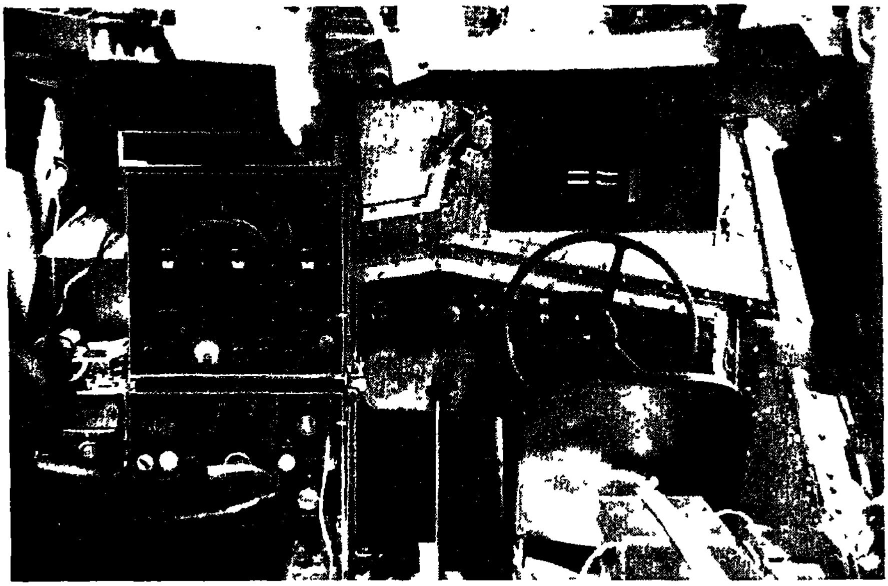

THE SPEARHEAD OF ANY MODERN INFANTRY ATTACK—

**Fig. 6.** *The main types of modern British tank are illustrated in this artist's impression of the "mechanized cavalry" which has so radically changed the appearance and performance of the British Army The fast light tank seen in the foreground is capable of eighteen miles per hour over rough country The semaphore signalling method illustrated is still the main system of communication between light tanks The compact, speedy Bren gun carrier has a road speed of forty miles per hour, and is equally efficient in difficult terrain Also*




"IRON HORSES" OF THE ROYAL TANK REGIMENT

*illustrated is the wireless-equipped "cruiser" tank, and the heavier sixteen tonner This latter machine, with its 3-pounder gun and its three machine guns, may be used in siege warfare to pave the way for an infantry advance, crushing all obstacles and annihilating enemy machine gun posts with its heavy armament Heavy tanks have been developed more especially by the French Designed to pave the way for big infantry attacks against enemy fortifications and strongholds, these monsters may well weigh anything up to seventy tons.*



INTERIOR OF A LIGHT TANK

*The wireless operator sits on the left and the driver on the right. When the visor is closed as here, the driver has to look through the small slits in front of him*

It was soon to be proved that the new weapon was capable of more than transient success. The Mechanical Warfare Department produced improved tanks, and despite a proportion of failures the improvements were real and rapid. Shortly after tanks took the field they became known as the Heavy Branch Machine Gun Corps, the Tank Corps was formed in July, 1917. Only four months later the corps was engaged in the first great tank action of the war, at Cambrai on November 20, 1917. Today the Tank Corps is officially known as the Royal Tank Regiment

Further uses to which tanks could be put, and their limitations, were discovered in the remaining year of hostilities. At Amiens, on August 8, 1918—the greatest tank battle fought—it was found that they could harass a retreating enemy to the point of demoralization But by this time anti-tank devices had appeared, and methods of countering an attack by troops in mechanized armour were being evolved.

The latest methods of meeting tank attacks are based on three inherent disadvantages common to all tanks.

(*a*) The bigger the tank, the better target it becomes for artillery. (*b*) Heavy tanks are relatively slow, and therefore vulnerable to traps, shell fire and anti-tank projectiles. (*c*) In heavily-armoured tanks the crew's vision is limited and the angles of observation restricted.

Successful anti-tank measures, as described in later pages, take advantage of one or more of these limitations

Although the tank was evolved for the specific purpose of moving through trench systems impregnable to infantry, its mobility was soon further exploited by the production of a "whippet tank" These lighter and smaller machines first appeared in 1918, and soon afterwards were being manœuvred in squadrons They were the forerunners of land fleets

in action. The method of countering tank attacks by other tanks may prove more effective than the normal anti-tank artillery, for the newest tanks can be adapted to many more phases of warfare than was foreseen when the weapon was first introduced into the army.

### TYPES OF TANKS

In general, tanks may be classed as heavy, medium or light (Fig. 6). The speed of the heavies may be only some six miles per hour, but the lighter modern tanks will move across normal country at a speed of twenty miles an hour with ease. Even so, the demands for extreme mobility have made armoured cars necessary as well.

Armoured cars are offensive machines, but as a class are distinguishable from tanks by the fact that they are wheeled. As the armoured car companies use tracked machines as well for cross-country work, hard and fast distinctions are difficult to draw.

A mixed tank battalion going into action is manœuvred rather like a fleet of ships in a sea battle. In advance are the light tanks, the scouts of the "fleet," which may be protected by close-support tanks carrying mortars firing smoke shells in order to form a screen that will hide these scouts from the enemy. Behind these are the larger fighting tanks, five of which form a section.

Changes are rapid in military science, and for this reason it is impossible to describe in detail every type of tank in use today. Nevertheless the general classes of heavy, medium and light tanks will always exist, and the special features of each class may be shortly mentioned

The standard British light tank (Fig. 7) is comparatively lightly armed It carries one Vickers gun and one .5-inch machine gun. It may weigh from $4\frac{3}{4}$ tons to 6 tons, and can be used for reconnaissance, for long-range outflanking attacks on positions behind the enemy lines, and also for turning a defeat into a rout by rapidly following up the retreating enemy. It is also heavily enough armoured to undertake the protection of medium tanks by attacking and putting out of action the enemy anti-tank guns. The light tank is obviously suited to the tactical employment formerly undertaken by the cavalry arm. For this reason it is not only included in army tank brigades, but has also become the mainstay of the new mechanized cavalry.

There are two types of medium tank (Figs. 8 and 9) which differ according to armament. The standard medium tank may weigh from $14\frac{1}{2}$ tons to 16 tons. It carries four guns, three being of the Vickers type, and one a 3-pounder. The medium tanks form the main striking force of the Tank Regiment. The first type is powerful enough to pave the way for an infantry attack, fast enough to break through to attack enemy batteries, and sufficiently well armoured to tackle strongly defended positions. The second type is the close-support tank. Its main duty is to accompany or follow fighting tanks into action and to destroy enemy anti-tank weapons Instead of being armed like the first type it carries a short-range mortar firing a heavier shell and a tube for laying smoke screens. It is very useful for concealing by a smoke screen the movements of the striking force

### ARMY LAND MONSTERS

Heavy tanks, or "infantry" tanks as they are frequently called, are the land monsters of the army, and have been developed more especially by the French. Their main duty is to pave the way for a big infantry attack in siege warfare. Shielded with thick armour they rumble slowly across the ground just ahead of the attacking troops, crushing down obstacles by sheer weight and power, wiping out machine gun nests and affording

cover to the men behind them. These functions can often be performed by medium tanks, but the heavy tank has been evolved in an attempt to overcome the superiority of defence over attack in modern warfare.

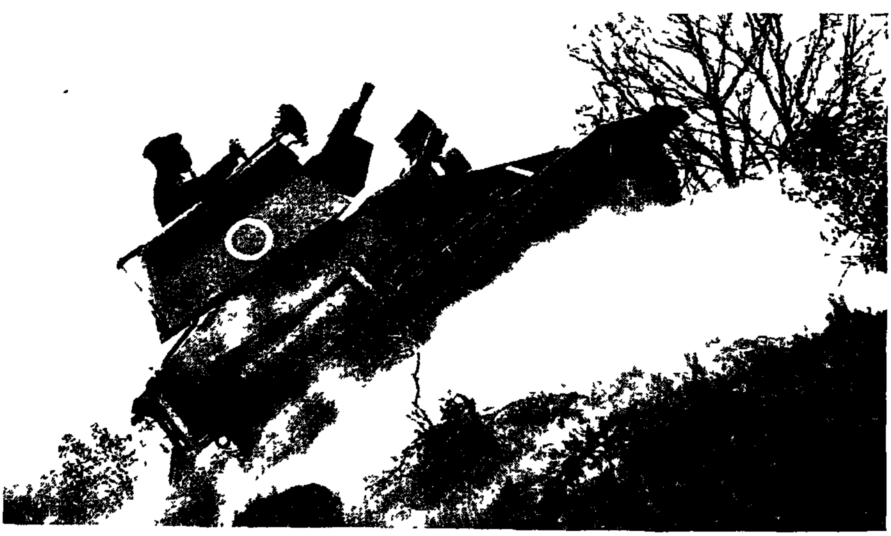
Armoured cars are used in quite a different way from tanks, for they are intended to operate on roads and open plains. They can be used anywhere as long as the surfaces over which they have to travel are good enough, and are employed extensively in certain types of desert warfare. They make long-distance reconnaissances with other mobile troops co-operating whenever they are required, and they are also used to escort convoys of transport and other vehicles

### REPAIR AND MAINTENANCE

All this reliance on machinery makes the repair and maintenance of army equipment a vital task. Every unit on war establishment has its artificers, equipped with hand tools and spares for front-line repairs. Supplementing these are the mobile workshops, included in all Royal Army Service Corps mechanical transport companies. For armoured cars, tanks, artillery and other equipment outside the responsibility of the R.A.S.C., a mobile workshop of the Royal Army Ordnance Corps is incorporated in each division (Fig 10). It can tackle almost anything in the way of repairs; but, being necessarily mobile, it is supported by other workshops with even greater facilities.

As never before, the Army is now a fighting machine and its skilled engineers and mechanics need all their resourcefulness to cope with the problems of maintenance. Although the machine may overshadow the man, he is nevertheless its master.

The day's work of a man serving the mobile workshop is always varied. His life is not governed by a bugle call and drill, but by the necessity to keep the army's machinery at fighting pitch.



"CAVALRY" OF THE MODERN ARMY

**Fig. 7.** *The British light tank has amazing manœuvrability and speed, and is capable of operating over the roughest country Here is a light tank of the Royal Tank Regiment climbing a hill side under smoke-screen protection during gas training*

HEAVILY-ARMED MEDIUM TANKS ADVANCING

**Fig. 8.** *The medium tank, backbone of the Royal Tank Regiment, is used to lead infantry attacks, for attacking enemy batteries, and destroying heavily-armed key positions*

A R A.O.C. man's day may start at any hour. And if he rises before the sun there will be night-accumulated work awaiting him There is always the workshop and service routine to be attended to—filling tanks, checking speedometers, compiling logs of mileage, and a hundred other routine jobs. And at any moment he may receive a call for field work

The R.A.O.C. personnel must have a special knowledge of many different types of machinery, for the machines they may be called on to handle during the day may be more delicate than tiny watches or more robust than steam rollers The variety of vehicles entrusted to them calls for every gift of the born mechanic. Perhaps it is a searchlight that is giving trouble, demanding repairs on the spot, or a tricky piece of machinery, like an anti-aircraft predictor, may be brought in for workshop attention.

The R A.O C. driver must be prepared for road problems of every kind, and he becomes remarkably skilful. He must be able to load his lorry expertly, and drive according to that load's requirements, watching for big bumps if his charge is delicate machinery, or opening up the throttle if the job is one that calls for speed He develops a road sense that is sheer instinct. In addition, he must be able to "smell out" likely short cuts, gauge distances, and take chances the ordinary driver would never risk. By the time that he returns with his load he may feel he has done enough for the day But when he has done one job he is sure to find that plenty more are waiting for him His headquarters is a clearing house for mechanized casualties, since the wear and tear of active service on vehicles of all kinds is enormous

### WORK OF R.A.O.C. DRIVER

The only chance a driver gets to rest may be at meal times. A telephone call may take him out on a breakdown job, and after that he may be needed for heavy repairs that will tax his physical fitness as severely as his skill

It may be getting dark before he returns from his last assignment, driving

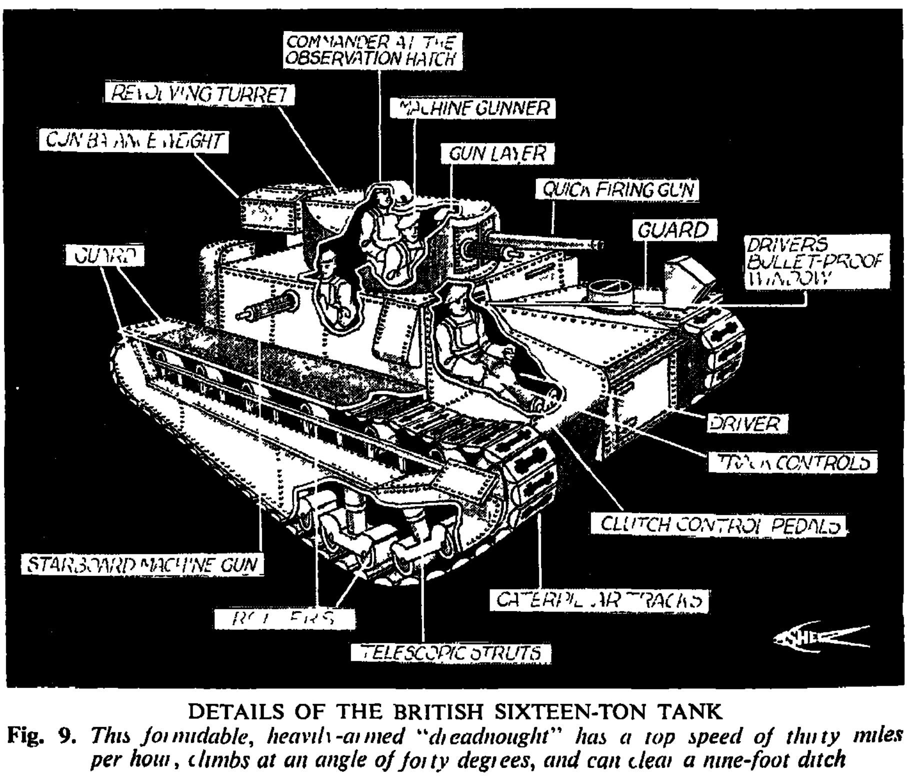
and nursing a refractory vehicle reported to be incapable of moving another yard. But he has brought it in successfully, and so avoided a spell of what even he, with his seasoned ability, admits is difficult work—driving at night, under army conditions.

Before he turns in for the night he may spare time to glance at a complicated smash that has come in and will have to be cleared up tomorrow. But, in fact, he thrives on the varied mechanical problems that are continually confronting him, and gets a real satisfaction from mastering the "impossible"—a word that seems to be unknown to the R.A.O.C.

Another specialist corps whose work has been increased by the new mobility of the Army, is the Royal Corps of Signals Its personnel must deal with the messages that weld all the scattered units into one army and to which we referred in the previous chapter. Under the new conditions it would often seem that the problems of communication were insoluble. To link together countless units, visual methods of signalling, including flags, heliographs, lamps, and rockets will always be necessary. But how are the vast main channels of communication to be established and kept working under war conditions.

Hundreds and thousands of miles of telegraph and telephone wires provide the answer. It is astonishing to what extent these are made available, despite the Army's disposition to keep moving.

Typical of the modern mechanized aids to communications is the mechanical telegraph cable layer This device is




DETAILS OF THE BRITISH SIXTEEN-TON TANK

**Fig. 9.** *This formidable, heavily-armed "dreadnought" has a top speed of thirty miles per hour, climbs at an angle of forty degrees, and can clear a nine-foot ditch*

BLACKSMITHS AT WORK OUTSIDE A R A O C MOBILE WORKSHOP

**Fig. 10.** *Mobile workshops of the R A O C. are attached to each division for the maintenance and repair of tanks, armoured cars, artillery and all equipment not serviced by the R A S C*

installed on a motor truck, and while the vehicle is being driven along roads or lanes the apparatus reaches out sideways and deposits the uncoiling wire from the drum along the hedgerows. The speed with which two distant points can be brought into touch by this method is almost phenomenal

On the other hand, for the purpose of linking units in the field over short distances there is a miniature wireless set, light enough to be carried anywhere by one man. Its loop aerial is directional, thus giving a considerable degree of selectivity and secrecy. The whole apparatus is sufficiently compact to stow into a pack that fits across a man's shoulders.

The Army makes use of every recognized form of communication. Valiant little carrier pigeons play their part in modern warfare, and with little aluminium message cases attached to their legs they have flown through heavy gunfire. Pigeons have also been equipped to carry tiny cameras, operating automatically to secure a series of exposures and so take close-up photographs of enemy positions. It is only by using such an amazing variety of methods that the Royal Corps of Signals achieves the miracles of communication demanded by the mechanized army of today.

GUN CREW IN ACTION

*The crew of a 6-inch howitzer ram home the shell. The charge, usually cordite or some other comparatively slow-burning explosive, is then inserted. The breech is then closed and the charge fired by a percussion striker.*

# CHAPTER XIII

# MODERN ARTILLERY

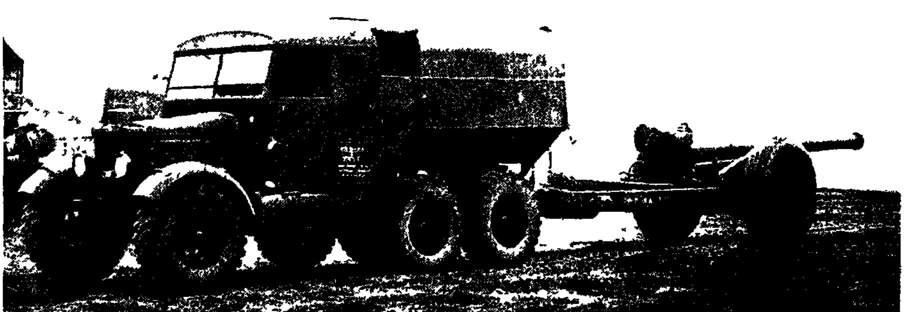
THE rumble of big guns in action is the most ominous sound of our times. It carries the fearful threat of controlled explosion, the deadliest weapon of scientific warfare. Despite the introduction of chemical weapons—corrosive, choking and blinding—the chief agent of wholesale destruction is still explosive.

The striking power of the modern army extends from the huge long-range guns that can hurl the heaviest projectiles for distances of over twenty miles to the lighter artillery with its more intensive and rapid fire used when the forces engage more closely. Finally, at close quarters, there is the incessant death rattle of the automatic weapons. Although strictly speaking, these are not actually "artillery" but "small arms," we shall give some description of them in this chapter.

Explosives of every kind depend on the almost instantaneous conversion of the explosive substance into a gas Compounds, such as gunpowder and its modern derivatives, which are of small volume in themselves, are made to undergo sudden chemical changes that cause them to produce enormous volumes of gas. This volume of gas is further expanded by the heat produced by the chemical change When the process takes place inside the breech of a gun, the gas can only escape through the muzzle. In order to do this it has to push the shell before it, and the propulsive power it can engender is almost unlimited.

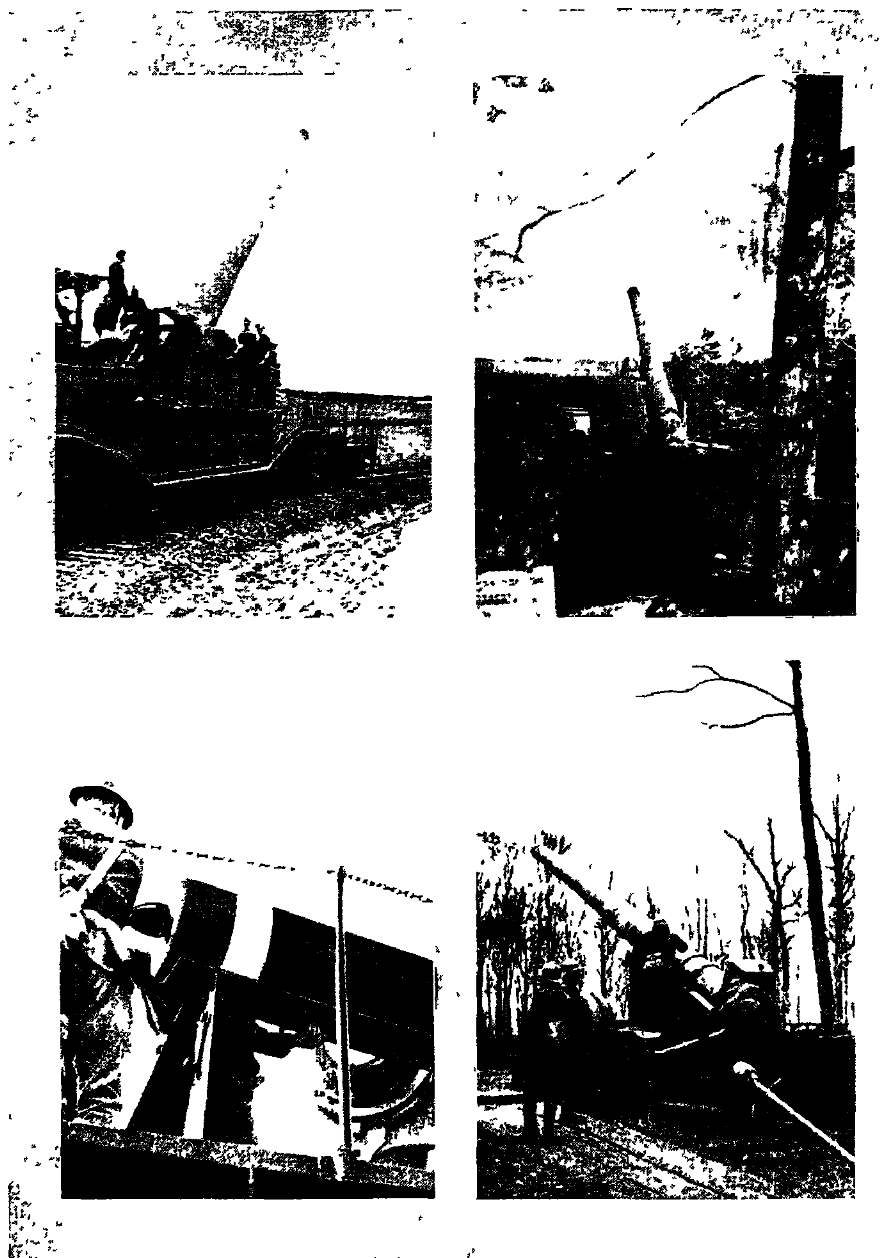
Although an explosion appears to be instantaneous, it really involves a series of events, each taking a measurable time. This period of time can be regulated by using different compounds for different purposes That is why there are so many types of explosives in use, and why new explosives are constantly sought by research workers.

For military purposes explosives are used in many different ways. For example, they may be required to propel a single small missile, such as a rifle bullet, or to shatter a missile that has been previously fired by another explosive, as in the case of a high-explosive



SCAMMEL TRACTOR HAULING A MEDIUM GUN INTO POSITION

*Formerly the size of field artillery was determined by the maximum weight that could be drawn by a team of six horses Today tractors can haul heavy guns into advanced positions*



[French Official Photograph

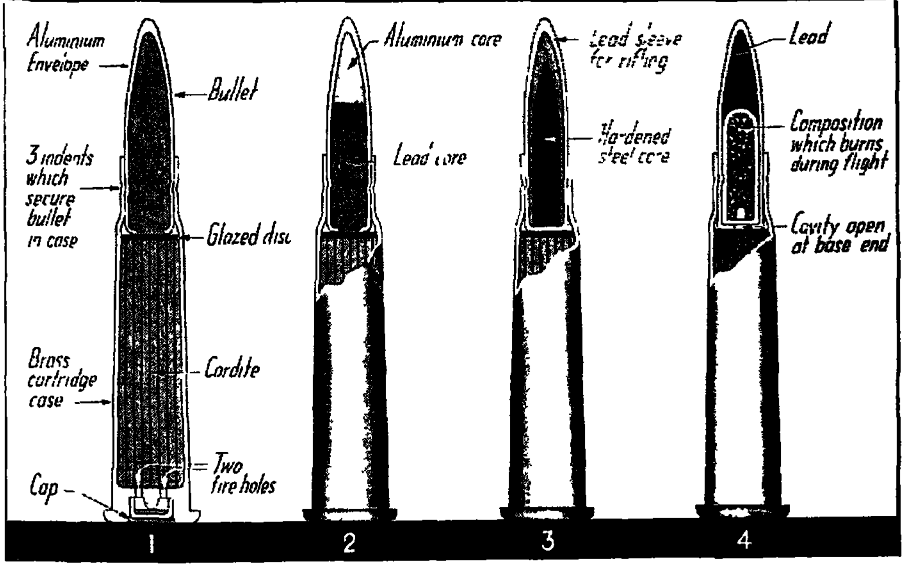
FRENCH HEAVY ARTILLERY ON THE WESTERN FRONT

(A) *Monster French gun on special railway mountings* (B) *Heavy gun concealed behind a wood* (C) *Gun crew loading a huge projectile into the breech* (D) *A huge gun mounted on a prepared emplacement Such guns are moved into position by tractors*

shell. In the latter case the explosion that fires the shell from the gun is quite different in character from the explosion that takes place when the shell detonates on the target. The ideal requirements of an explosive are that it shall be as powerful as possible, smokeless, and sufficiently stable to withstand ordinary conditions of manufacture, storage, climate and carriage.

An explosive is usually a mixture of substances that in themselves may not be of an explosive nature, but which when united by the application of heat or percussion produce the gases referred to above. For instance, very finely powdered iron has an enormous affinity for oxygen and can cause a violent explosion in favourable circumstances. Chlorates, when mixed with certain aromatic compounds, make powerful blasting preparations. Gunpowder itself is merely a mixture of carbon, saltpetre and sulphur, none of which in themselves would "explode." The saltpetre causes the other substances to burn rapidly, producing the requisite high pressure of gas to cause an explosion. Gunpowder, known as a "low" explosive, explodes by combustion and is effective only when burned in a confined space. If burned in the open air it merely gives off a large cloud of "smoke."

A gram of cordite occupies about one cubic centimetre, but when changed from a solid to a gas by the explosion it requires about 1,000 cubic centimetres of space at atmospheric temperature and pressure. It requires several thousands of times as much space at the temperature it is at when exploded by the flame from the detonator, its temperature then rising to the neighbourhood of 2,000° C. One cubic centimetre of cordite in a cartridge produces enormous pressure on the base of the bullet or shell behind which the explosion takes place. Behind a rifle bullet it is nearly two tons. There is




TYPES OF SMALL ARMS AMMUNITION

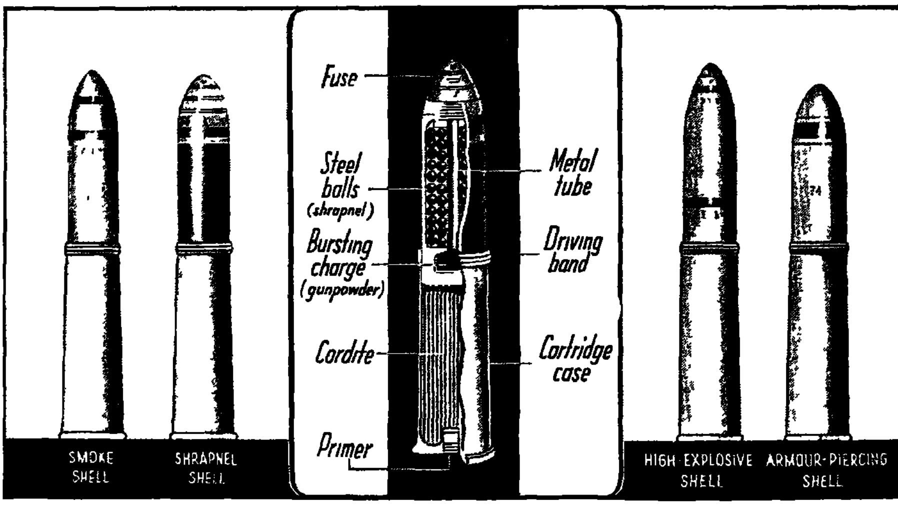
**Fig. 1.** *Four types of ammunition used by modern infantry 1 and 2 are ball cartridges, 3 is an armour-piercing bullet, and 4 a tracer bullet which burns and makes its flight visible.*

only one outlet by which the expanding gas can escape and that is down the barrel of the rifle. Before it can reach the open atmosphere, however, it must drive the bullet before it, and so the bullet speeds on its way in whichever direction the rifle is pointing at the time of the explosion As the expanding gases issue from the barrel they cause a sudden and violent wave of compression in the atmosphere, and this, impinging on our ears, causes the sharp report of the discharge Fig 1 shows some details of small arms ammunition.

Not all explosives have the same effect, and as a rule a specific explosive is used according to the effect required For example, in quarrying when it is desired to dislodge a quantity of rock, it is preferable to use a slow-burning explosive that will rend the rock apart rather than break it up. On the other hand, when it is desired to destroy a building by artillery fire, an explosive is used that has a more violent and shattering effect.

Some explosives are more effective than others because their gases require a larger space for expansion. One of the most powerful is trinitrotoluene, familiarly "T.N.T.," 1½ lb. of which as a gas at atmospheric temperature and pressure would occupy 3,600 pints in volume. The explosion of this amount of T.N.T. turns it instantly into a white-hot gas which at the temperature of the explosion would occupy about 18,000 pints—resulting in a pressure of practically 200 tons to the square inch. A T.N.T. bomb thus causes an enormous compression wave in the atmosphere, with devastating effects on the buildings near where it falls. If T.N.T. were exploded by shock alone, a shell containing it could not be fired from a gun It is exploded by detonating in it a small quantity of an explosive, such as fulminate of mercury

Without such a detonator, explosives of this class can be handled safely. On one occasion, Lord Haldane, when Minister of War, came to the House of




FOUR TYPES OF MODERN SHELL

**Fig. 2.** *Modern artillery uses a diversity of weapons firing many different projectiles Smoke shells are used to cover advances or retreats Shrapnel shells, exploding in mid-air, shower death on the enemy from above High-explosive shells shatter buildings and destroy enemy batteries Armour-piercing shells are used against tanks*

MODERN SUCCESSOR TO "BIG BERTHA"

*Germany has established a tradition for experiments with "outsize" guns This modern monster, a successor to "Big Bertha," famous in the war of 1914-18, has a barrel of unusual length Notice the special bracing to prevent sag Such a gun may have a range of over a hundred miles its shell might reach a height of thirty miles at its maximum trajectory.*

Commons using as a walking stick a stick of dynamite, which is nitro-glycerine—an oily liquid discovered by Nobel in 1869 combined with silica or wood pulp. As Lord Haldane explained to his startled colleagues, there was no danger so long as there was no detonation!

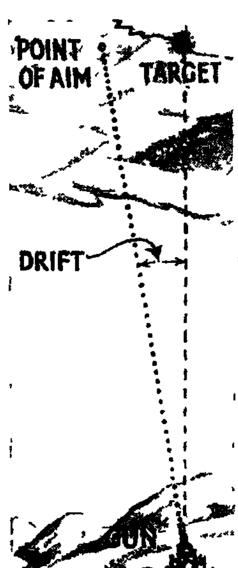
We have referred to gunpowder as a low explosive. Explosives such as T N T belong to a different class and are known as high explosives, abbreviated "H.E"

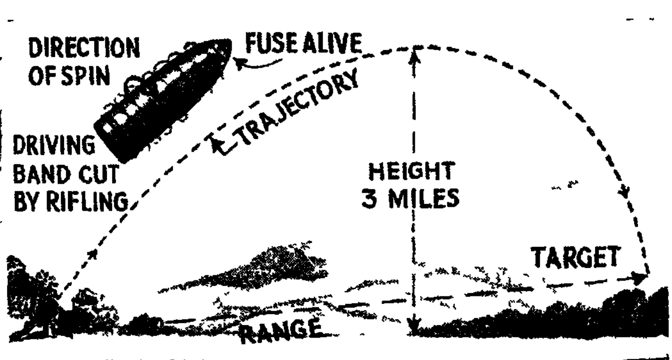
### HIGH EXPLOSIVES

High explosives are those in which the expansion time factor is comparatively very short With this class of explosive the change from the solid to the fully-expanded gas takes place too quickly to be used for artillery propulsive purposes, for it would burst the gun barrel. High explosives are used to shatter the shell when it has reached its objective.

For propelling the missile an explosive producing a gas that expands relatively slowly is required. Cordite is an explosive of this type. It is a buff-coloured substance consisting of nitro-glycerine, guncotton and mineral jelly Its name is derived from the fact that it is issued in the form of cords or strings of different diameters, obtained by passing the substance through dies of varying sizes. For large guns these cords may be half an inch thick and three feet in length, a number of them being grouped together in the form of a cartridge about the size of a drainpipe. Cordite is smokeless and burns evenly, developing its enormous power at a rate so controllable that it may be used even for the largest guns. The rate of combustion of cordite is however, only relatively slow, for it can force a shell out of the barrel of the gun at a velocity of more than 1,500 miles an hour! The shell of an 8-inch howitzer weighs about 200 lb. and leaves the muzzle of the gun with a velocity of nearly 2,000 feet per second. It will strike a target five miles distant at a velocity of 1,000 feet per second. Some types of shells in use are shown in Fig. 2

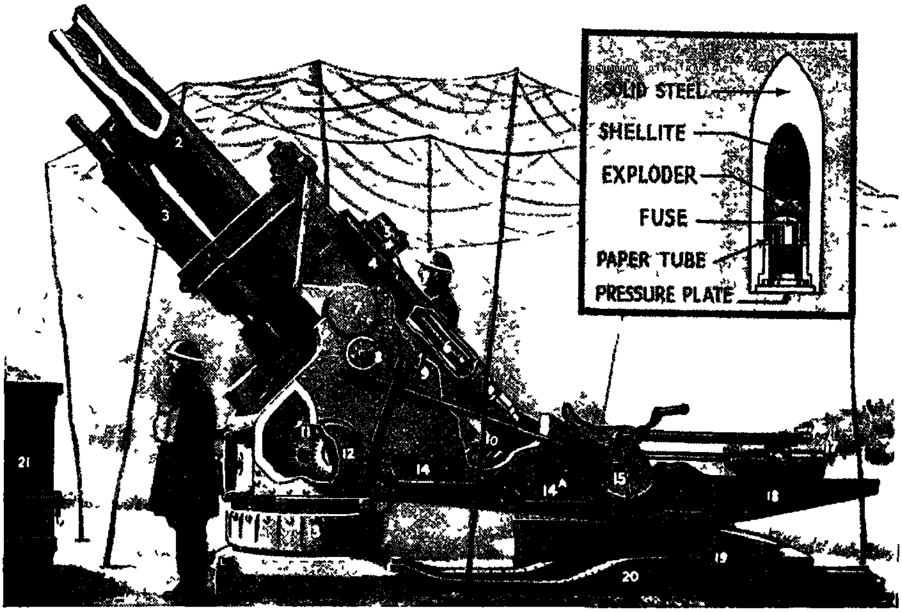
All shells have a copper driving band fitted on their bases (*see* page 256), which




FLIGHT OF A HOWITZER SHELL

*The shell from a big howitzer may rise to a height of three miles or more The rifling inside the gun barrel, acting on a copper band at the base of the shell, imparts spin to keep it steady (above) The spin also releases the safety catch in the fuse and makes it "alive" All British guns are rifled to the right, and this causes the shells to spin and drift to the right The gun is therefore aimed to the left of the target (left)*




BRITISH 9 2-INCH HOWITZER AND ITS SHELL

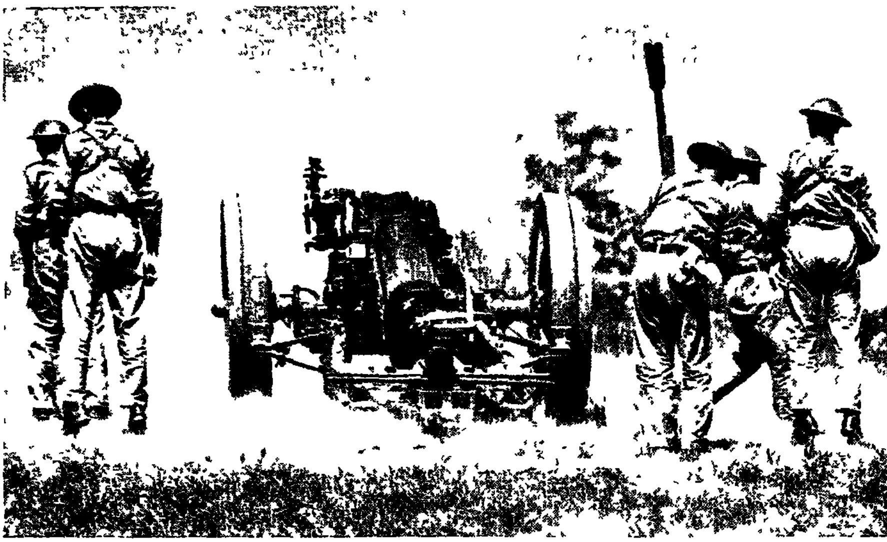
**Fig. 3.** *The 9 2-inch howitzer has a crew of four men, and can throw its huge shell eight miles 1, Barrel and interior rifling 2, Recoil slide 3, Recuperator 4, Recoil cylinder. 5, Oil cylinder 6, Recoil piston and rod 7, Trunnion 8, Traversing handle 9, Elevating handle 10, Breech 11, Elevating arc and gears 12, Gear case 13, Foundation ring 14, 14a, Platforms for gunners 15, Shell loading hand gear 16, Mechanical loading arms 17, Shell ready for loading 18, Shell platform 19, Traversing platform 20, Foundations 21, Earth-filled box which helps to keep the gun steady Inset are details of the shell*

when engaging the rifling gives them the spin that keeps their flight true. The velocity of an 8-inch shell is so great that it spins at 5,800 revolutions per minute. By centrifugal action this rotation releases a safety catch inside the fuse, which renders it fully sensitive so that it detonates immediately it strikes its objective. The copper driving band also seals the bore of the gun and prevents any loss of power from escaping gas pressure.

As already explained (*see* page 248), the length of a gun is measured in "calibres," so that the length of the bore is calculated in terms of diameter of the shell For example, in the case of an 8-inch gun the ten-feet-long barrel would be said to be fifteen calibres The spin given to the shell fired from a gun like this would be only one turn in twenty feet of travel, so that the rifling inside the barrel, which gives the "twist" to the shell by means of the copper band, would make only half a turn in the gun

Another important type of shell is the shrapnel-filled projectile. The shrapnel shell (*see* centre Fig. 2) contains a number of bullets that are scattered at a predetermined moment by a bursting charge. Its deadliness is due to the difficulty of taking cover from a hail of bullets coming from directly overhead, but today the parapets of defence works are usually constructed to provide protection against this form of attack.

In order to detonate high explosives, a very sensitive explosive such as



AUSTRALIAN TROOPS FIRING A 6-INCH HOWITZER

**Fig. 4.** *The 6-inch howitzer is classed as medium artillery and the shock of its discharge can be gauged by the attitude of this gun crew Notice that they are braced on their toes*

fulminate of mercury is used. It is used in cartridge cases and in fuses which can be set in action by a time device, by the impact of the shell on its target, or by centrifugal force, as we have already mentioned. Lead azide is also used as a detonator.

These various classes of explosives are used and fired by a host of artillery weapons, each developed for some special use and all inter-related. Let us start by describing the largest guns. The guns normally used in warfare fall into three classes—heavy, medium and field. Experiments have been made with freak guns, like the famous "Big Bertha" which had a calibre of 8¼ inches and fired a 228-lb. shell eighty miles Guns like this, fortunately, are expensive and of short life, and better results can be obtained by bomber aircraft.

The chief guns classed as heavy artillery are the 18-inch, the 16-inch, the new 14-inch, the 9.2-inch (Fig 3), and the 8-inch howitzers, some of these guns having ranges of 35,000 yards (20 miles) The heaviest of these are really naval guns. Medium artillery includes the 4.7-inch, the 60-pounder, and howitzers firing 6-inch shells (Fig. 4). The ranges of medium guns vary from 10,000 to 21,000 yards. Field artillery includes 18-pounder field guns and the new 25-pounders (Figs. 5 and 6). The maximum range of field artillery is about 14,000 yards. Heavy artillery is used in attacking distant objectives behind the enemy lines, and the medium and field artillery for shelling trenches or similar objectives at a comparatively close range Recent mechanization has considerably extended the use of large guns, and today powerful tractors are employed to haul them to positions formerly considered inaccessible. Thus, large guns, which formerly would only be fired from permanent fortresses, can now be fired in the field

Until the recent mechanization, the power of field artillery was determined

by the maximum weight that could be drawn by a team of horses—generally six. Because of this, field guns were limited to a weight of about two tons Heavier guns were either mounted on special trucks and used on railways, which somewhat limited their sphere of usefulness, or were mounted on specially built emplacements behind the lines.

The early guns were attached to their mountings by trunnions that fitted into slots in the carriage, enabling the gun to be elevated or depressed on its mounting. Both gun and carriage recoiled together, running back for several yards All modern gun barrels are mounted inside a cradle and when fired recoil within it, the mounting remaining stationary. A recoil-checking device keeps the gun in the cradle and this does not recoil with the gun. The recoil is absorbed by hydraulic buffers, a part of the energy of recoil being used to bring the barrel into position for the next round. The gun sights are fixed on the mounting instead of on the barrel as formerly, and, as the gun does not shift its position, continuous laying can be carried out

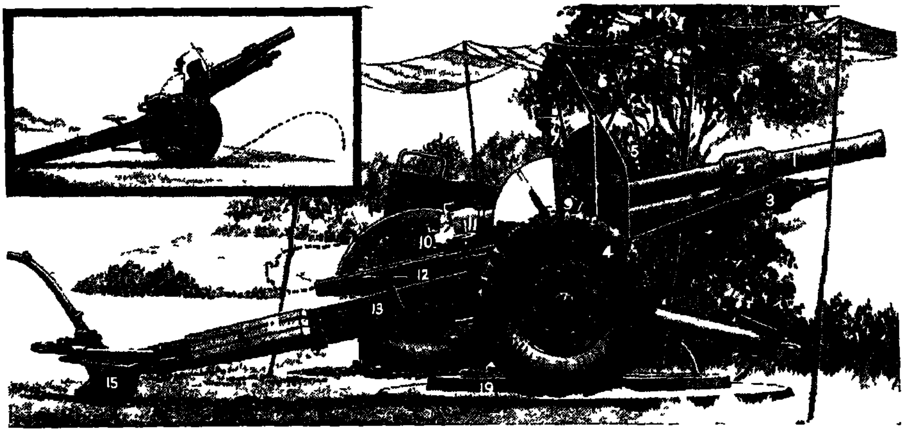
Actual firing is carried out by means of tubes—electric or percussion—or primers. The tube is placed in the vent. whilst the primer is screwed into the base of the metal cartridge case. When electric tubes and primers are fired a current heats a platinum wire and so ignites the powder in the tube (*see* page 254). Percussion tubes have a percussion cap that is fired by a striker

Howitzers are low-velocity pieces with a high angle of fire, whilst guns have a higher velocity and a flatter trajectory Howitzers are more particularly used for destroying concrete fortifications and other heavy emplacements Not only have the large shells great destructive power, but they are rendered more effective by the steep angle at which they fall on their target. A recent type nicknamed the "gun-how" (Figs. 5 and 6) combines the best of the field gun and the howitzer.

In this type of shooting the targets are generally invisible from the battery position, which is normally located behind high ground to give cover. In such cases the guns are laid on their target by means of instruments. As the shell may travel to a height of four miles

A 25-POUNDER GUN-HOWITZER IN ACTION

**Fig. 5.** *The 25-pounder is one of the latest weapons to be added to British artillery. It combines advantages of both field gun and howitzer, and can be used as either*




BRITISH ARMY'S NEW WEAPON—THE GUN-HOWITZER

**Fig. 6.** *This 25-pounder, nicknamed "gun-how," can be used as a gun or, because of its high angle of elevation, as a howitzer (see inset) 1, Barrel 2, Oil reservoir 3, Recoil and recuperating cylinder 4, Balloon tyres 5, Shield 6, Sight slot and flap 7, Sights 8, Range indicator 9, Traverse handle 10, Breech 11, Elevation handle 12, Cradle 13, Trail 14, Tool box 15, Steadying spade 16, Towing ring 17, Trail handle 18, Position of breech in full recoil 19 Platform for traversing gun*

or more, due allowance must be made for drift due to wind pressure and the effect of rifling. British shells drift to the right: German shells to the left (*see* illustration on page 372).

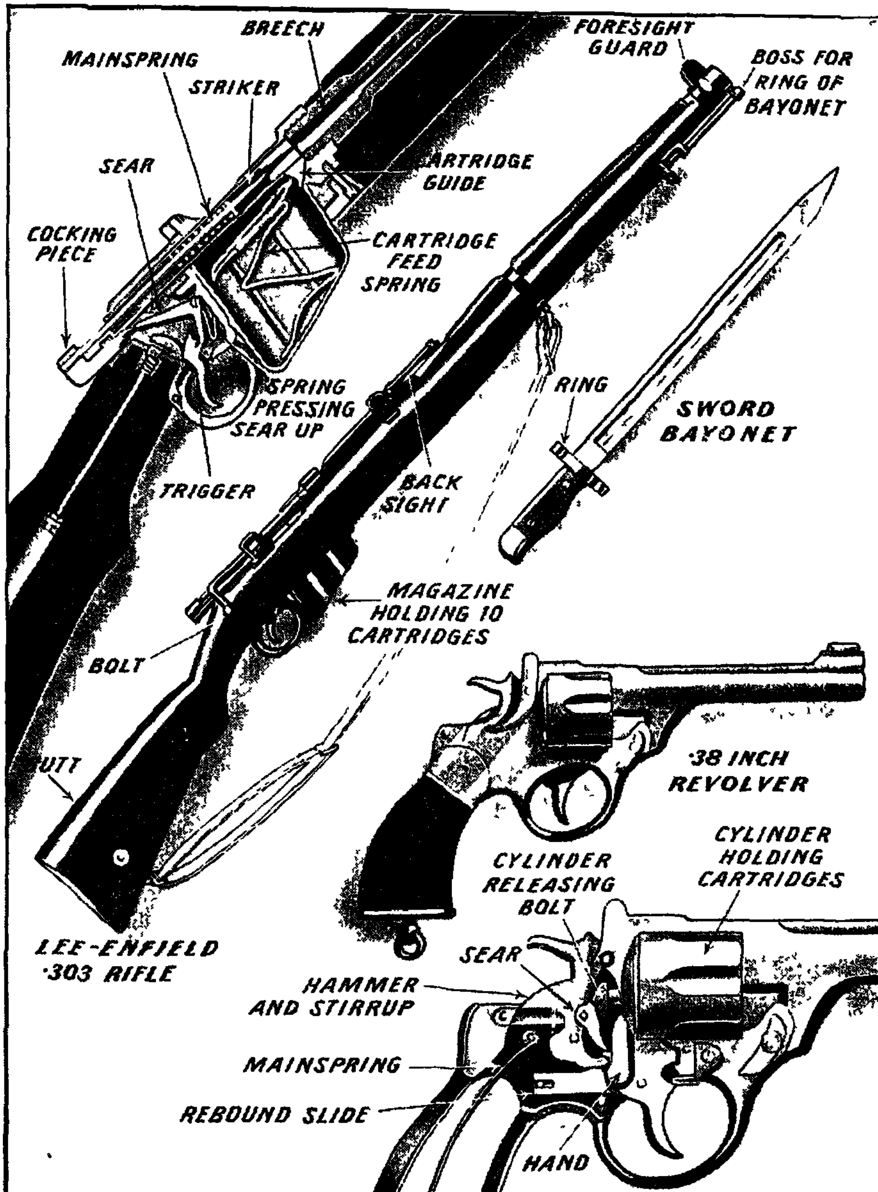
At the other end of the scale are the small arms carried by the infantry. Here mechanization has resulted in the mass use of automatic weapons that have all the advantages of being small and light, and also have extremely rapid rates of fire. Between the two extremes are trench mortars and other pieces of artillery, firing various types of projectiles including gas shells, smoke bombs and incendiary shells. It is variety in power, range and method that makes the modern artillery arm so formidable

**INFANTRY WEAPONS**

Infantry weapons of attack comprise the rifle, 3-inch mortar, heavy machine gun (Vickers .303 inch, costing £200), light machine gun (Bren), anti-tank gun, rifle grenade, hand grenade and revolver The revolver which fires six rounds of .38-inch ammunition, is normally used for fighting at close quarters, but the rifle is still the true personal weapon of the soldier. Some details of rifles and revolvers are shown in Fig. 7.

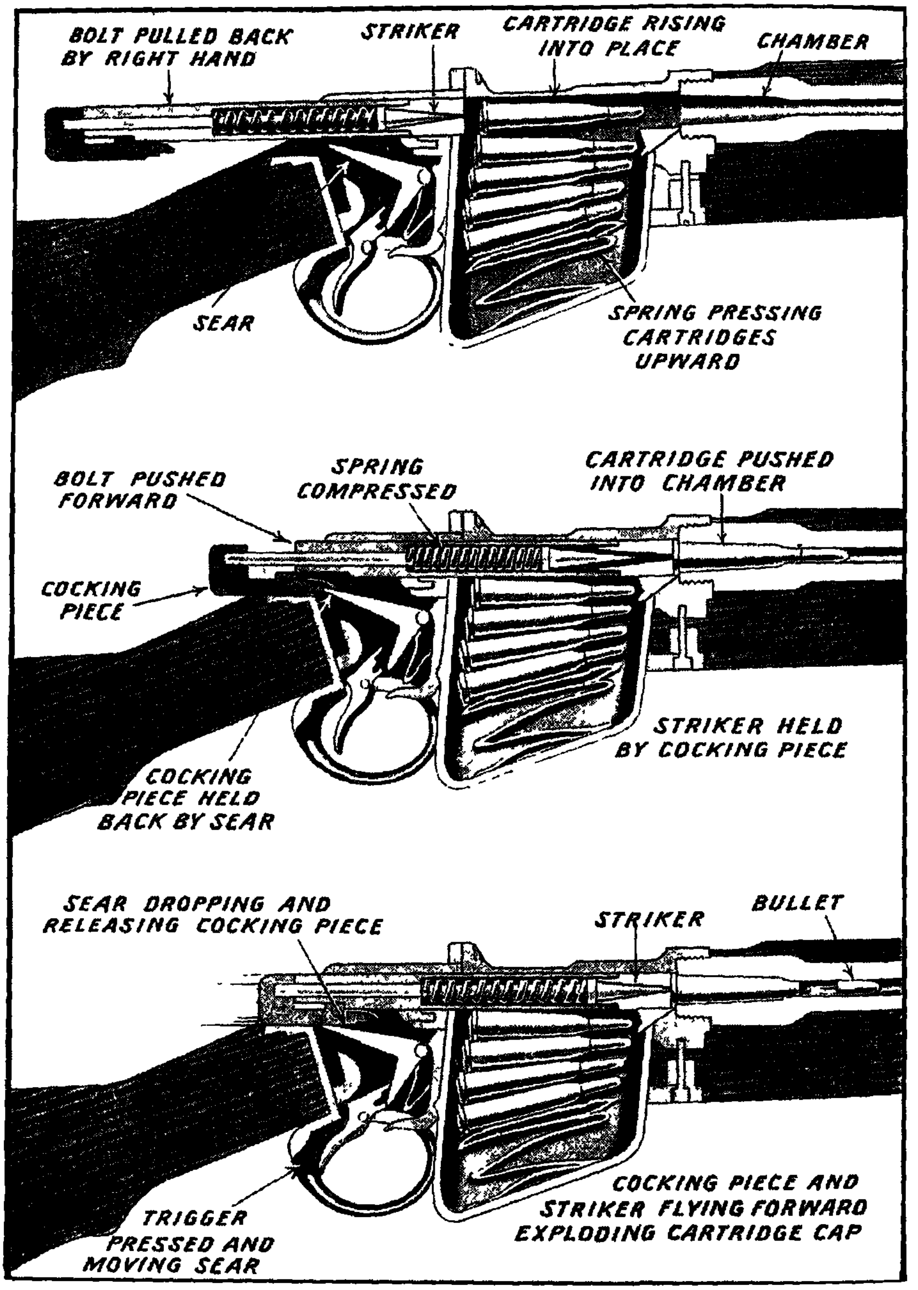
The standard service rifle of the British Army is the Magazine Lee-Enfield (M.L.E.), .303-inch bore and it costs £8 It consists of some hundred and thirty separate parts and the barrel will withstand a pressure of twenty-six tons to the square inch. Fig. 8 illustrates how the rifle is fired. The raising of the bolt lever causes the mainspring to be compressed, at the same time withdrawing the striker. When the bolt is pushed forward and turned down, the sear—an L-shaped piece of mechanism—engages, and the cartridge is forced home. When the trigger is pressed, the cocking piece, together with the striker, flies forward. The magazine holds ten rounds, fed to the cartridge chamber by a spring.

It is the accuracy of the rifle that makes it so valuable. The limit of its effective range is about 1,000 yards—at which




PERSONAL WEAPONS OF THE INFANTRYMAN

**Fig. 7.** *In spite of the coming of the Bren gun, the rifle is still the principal weapon of the infantry. The British Army is equipped with the Magazine Lee-Enfield, ·303-inch bore. It has a decisive range of 600 yards, and fifteen aimed shots per minute constitute rapid fire. The bayonet can be fixed to the top of the rifle. The standard ·38 revolver (bottom right) is also used for fighting at close quarters.*




MECHANISM OF THE MAGAZINE LEE-ENFIELD

**Fig. 8.** *When the bolt is pulled back, a cartridge rises (above) As bolt is pushed forward, the cartridge is pushed into the chamber The cocking piece is held back by the sear (centre) When the trigger is pulled the striker flies forward to explode the cartridge (below)*

distance the bullet takes approximately four seconds to reach its target—the limit of decisive range being 600 yards or thereabouts. The rifle has a flat trajectory and when it is fired by a man lying on the ground its bullet keeps within six feet of the surface for a distance of about 600 yards. Thus any one standing up or attempting to advance within this range is liable to be hit. For distances over 600 yards the trajectory is higher, and the weapon is therefore less effective. The term "long range" covers distances up to 2,000 yards, while distant range extends to 2,800 yards. At this latter range, which is the limit of sighting, the bullet rises to more than 700 feet and takes about ten seconds in its flight.

The normal rate of fire is five aimed shots per minute, but this can be greatly increased by training, and fifteen aimed shots per minute constitute rapid fire. So devastating is rapid fire from the Lee-Enfield that, in 1914, during the retreat from Mons, the Germans believed that they were being opposed by machine guns. This was a remarkable tribute to the Hythe School of Musketry, where the men were trained, and to the vision of Lord Roberts and others who foresaw the importance of the weapon.

Exploiting the rifle's extreme accuracy, snipers can play an important part in war (Fig. 9). Lying motionless for hours, camouflaged in all sorts of strange ways and often in full view to disarm suspicion, they can take steady toll in the opposing trenches. The new musketry training, using landscape targets instead of "bull's eyes," encourages the marksman to specialize in this class of work.

### RIFLE VERSUS TANK

Although rifle bullets are not effective against the armour of the modern tank, they can help to stem a tank advance if fire is concentrated on the tank's apertures. If the driver of the tank can be made to close his visor during an advance he is more or less blinded, and the

RIFLEMEN OF A HIGHLAND REGIMENT

*When fired by a man lying on the ground, the rifle bullet keeps within six feet of the surface for a distance of 600 yards. The normal rate of fire is five aimed shots per minute*

[British Official Photograph Crown copyright

"WITH DEATH IN THE CROOK OF HIS FINGER"

**Fig. 9.** *Snipers exploit the rifle's extreme accuracy For hours on end they lie motionless in front of the lines, taking steady toll of the opposing trenches Sometimes they camouflage themselves and lie in full view of the enemy At other times they take advantage of the cover offered by trees or mounds Brilliant marksmanship and a steady nerve are the qualifications for this dangerous work This sniper is practising his skill while poised in a tree*

fighting power of the vehicle is greatly reduced. The gun portholes also make suitable targets for rifle fire.

Less individual than the rifle, but with a most sinister reputation for deadliness, is the machine gun. More than any other weapon, it was the machine gun that caused the failure of the great Somme offensive in 1916, despite the fact that the ground was heavily shelled before the British advance.

The machine gun has several drawbacks, however. It is heavy, difficult to conceal before it comes into the open, and requires two men to carry it. Something more mobile was required. The answer came in the form of an automatic rifle or light machine gun, known as the Lewis gun (Fig. 10).

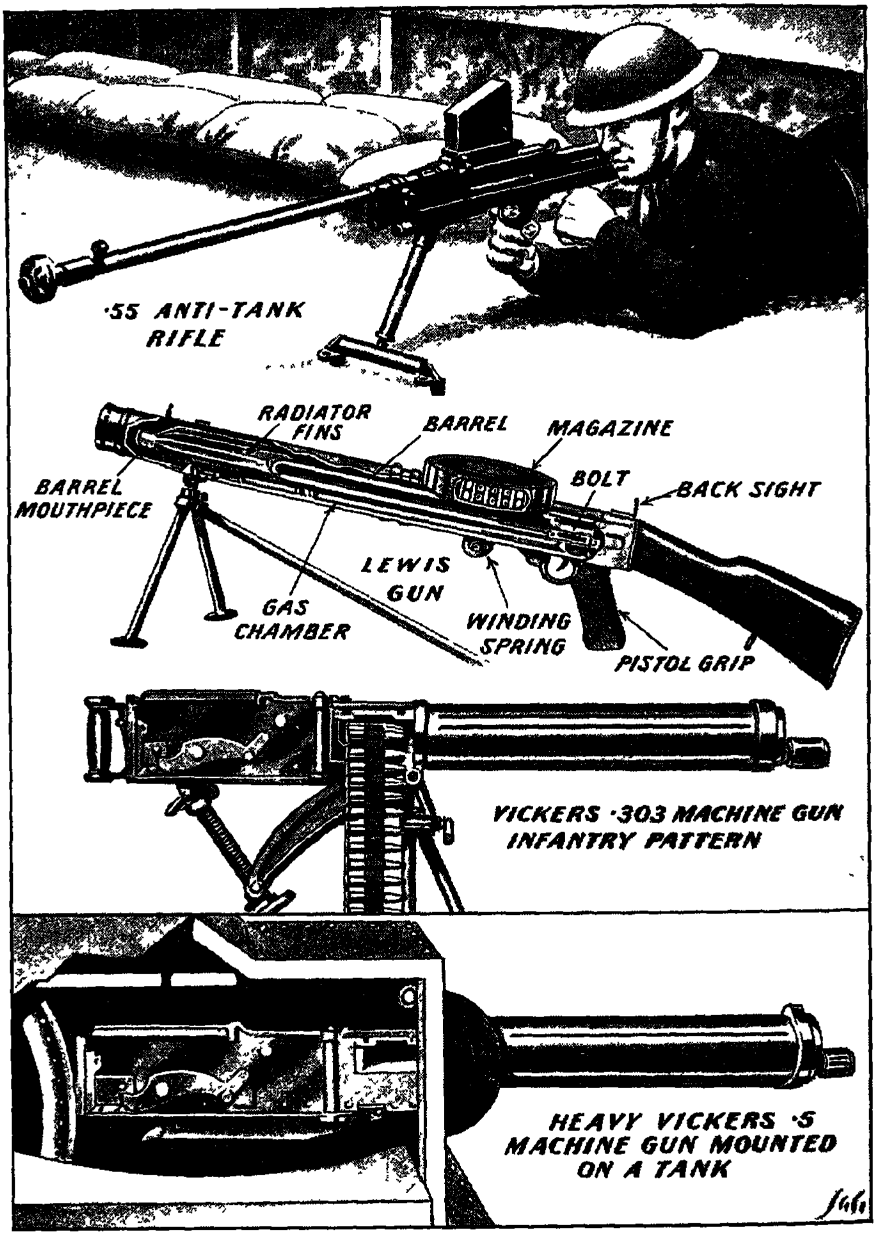
This gun, which costs £60, is light and easily portable and is used extensively both by infantry and by aircraft. The magazine holds forty-seven rounds and they may be fired singly, in groups, or continuously if the trigger is held back A piston, forced back by gas from the fired cartridge, brings the following round into position automatically.

The latest type of automatic used by the Army is the Bren gun (Fig. 11). Its name is derived from two sources—Br from Brno, the former Czechoslovakian arms centre, and -en from Enfield, famed for its small arms factories. The Bren gun is even lighter and more portable than the Lewis gun, and although the rifle is still the personal weapon of the infantryman, every rifleman in the British Army is now also trained in its operation.

The Bren gun may be used from a trench or in the field, from a tank or for anti-aircraft defence Single shots may be fired or the fire may be continuous, the rate of fire being controlled by a regulating valve in the barrel. Unlike the Lewis gun, the .303-inch cartridges of the Bren

CANADIANS MAN A HEAVY MACHINE GUN

*The machine gun, more than any other weapon, is responsible for the power of defence over attack in modern warfare It is capable of a very high rate of fire*




AUTOMATIC WEAPONS OF MODERN INFANTRY

**Fig. 10.** *The ·55 anti-tank rifle (above) is 5 feet 4 inches long, and this extreme length gives it a deadly accuracy. It fires a bullet that can pierce armour at a range of 500 yards. The Lewis gun (centre) is operated by gas and its magazine holds forty-seven rounds. Heavier machine guns are the Vickers ·303 used by infantry, and the Vickers ·5 used by tanks.*

gun are contained in a double row in a vertical magazine, and are guided to the firing chamber by grooves. Four men can keep up a continuous fire, one of them firing the gun, one observing, and the other two bringing up the ammunition. Its magazine holds thirty rounds, the normal rate of fire being one hundred and fifty aimed shots per minute. Bursts of fire at short intervals are most effective in attack.

The weight of the Bren is 21 lb. some 6 lb. lighter than the Lewis gun—and it is very accurate up to 600 yards. It can be fired from the shoulder, from a bipod, or from a tripod. It is on this last that it is elevated for use as an anti-aircraft weapon.

With its bipod attachment the gun can be operated—and even moved from place to place—by only one man. Because of its portability, handiness and all-round efficiency, it has become a "second rifle" to the infantryman.

The Bren is air cooled, but as continuous fire soon overheats any gun the barrel can be changed as soon as it becomes too hot. No tools are required for this operation, for the wooden handle on top of the gun by which it is carried serves also to handle it when hot. The change over can be made in a few seconds

Another feature of the gun that excites comment is the flash protector which is bell shaped and fixed to the end of its barrel. Actually, this is not part of the barrel, but is a separate piece of metal fitted over the muzzle to hide the flash when firing at night.

Much of the ease of handling the Bren gun is due to the fact that it is operated by gas. By means of an ingenious valve arrangement, some of the gas produced by the propellant's explosion is side-tracked, so that it ejects the cartridge that has been fired. The exhausted gas then escapes, and a spring pushes a fresh cartridge into place ready for firing.

The many advantages of the Bren gun have made it possible to simplify the organization of an infantry battalion and to reduce its size. At the same time, the fire power and mobility of the battalion as a whole have increased

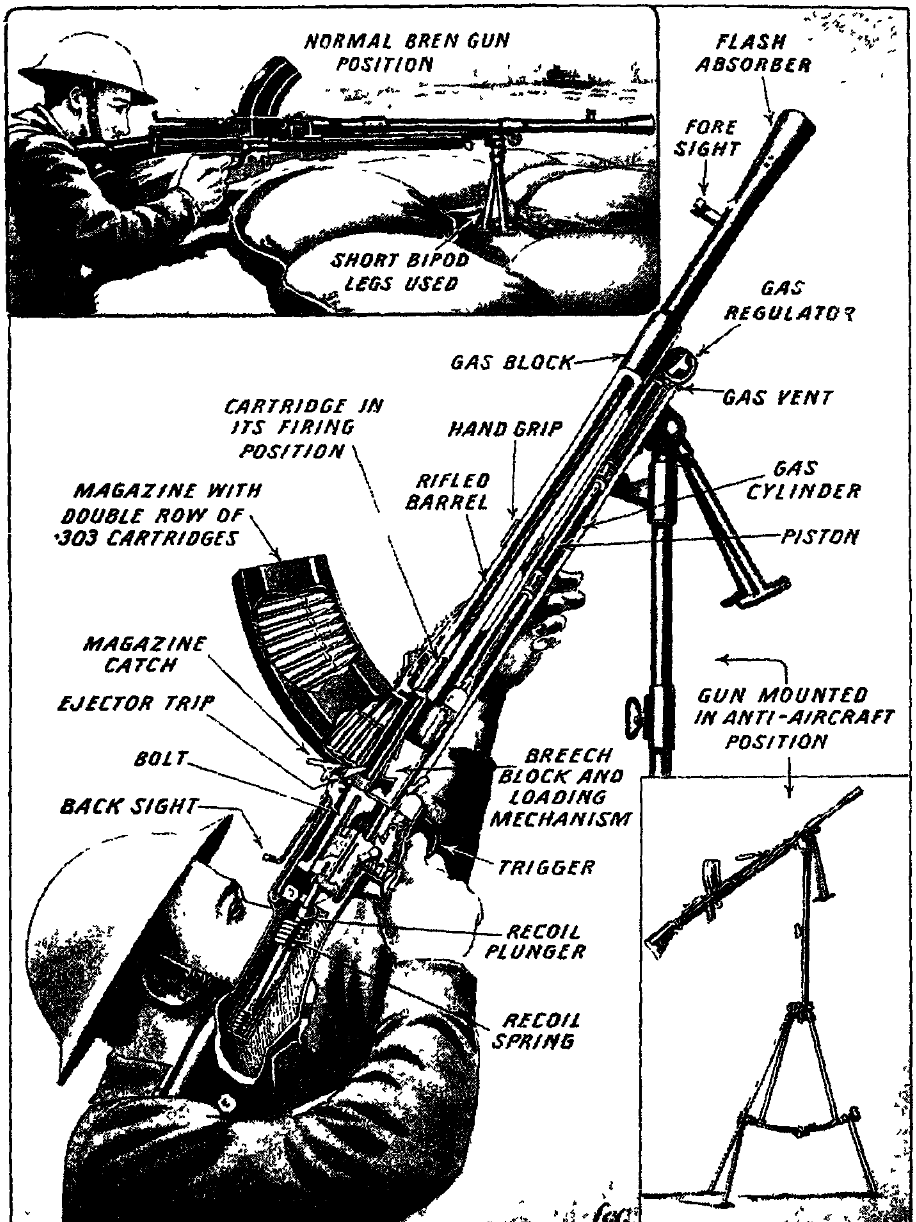
It must not be thought, however, that Lewis guns and Bren guns have taken the place of the heavier machine guns. While Bren guns form part of the equipment of every infantry platoon, the heavy machine gun is retained as a weapon for covering fire.

In attack, the forward heavy machine guns may be transported in carriers, ready to advance with the forward rifle companies. The supporting machine guns must protect the flanks of the forward companies, close any gaps that may appear, and deal with local checks that threaten to hold up the advance. Reserve machine guns are held in readiness to act

*[British Official Photograph Crown copyright*

BREN GUN DEFENDS CONVOY

*The Bren gun can be mounted on a lorry and used to beat off attacks by low-flying aircraft It is used extensively for this purpose by the R A.S C.*




HOW A BREN GUN WORKS

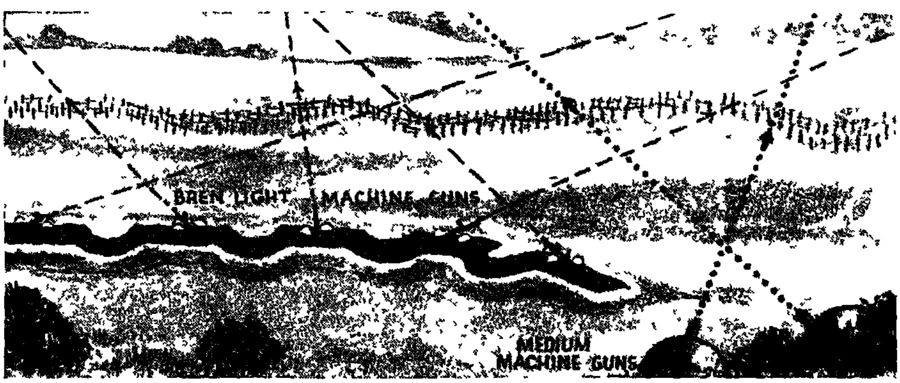
**Fig. 11.** *Every infantryman is now taught to operate the Bren gun It can be fired from the shoulder, from a bipod (inset above), or from a tripod (inset below) for anti-aircraft work Some of the gas produced by the explosion is side-tracked through the gas vent at the top of the barrel to the gas cylinder at the side, where it is used to eject the spent cartridge*

either as supports or as forward machine guns, according to the enemy resistance encountered. It is calculated that one machine gun can counter enemy defence measures over some fifty yards of front, so that a platoon of four machine guns covers about 200 yards. The normal method of fire is direct, but when the target is not visible from the gun indirect laying is resorted to and is controlled from an observation post, as in the case of artillery fire. Fig. 12 shows the method of cross fire in defence.

The rate of fire varies according to the needs of the moment. For slow fire a belt of Vickers M.G. ammunition, containing 250 rounds, is fired in four minutes. Medium fire is at twice this rate, and in rapid fire the whole belt of 250 rounds is expended in one minute. The normal first-line supply of ammunition carried in the field is 3,500 rounds for each gun.

The Vickers .303 machine gun, known as the heavy machine gun to distinguish it from the Bren, has many important roles allotted to it The large volume of sustained fire of which it is capable is its chief recommendation. There are other advantages, however, including the ability to fire in darkness or in fog along lines that have been determined beforehand. Heavy machine guns, moreover, do not make large targets, and can easily be concealed from enemy observation. On the other hand, the Vickers .303 is a water-cooled weapon, and so, unlike the Bren, when firing at the rapid rate it must be refilled with water from time to time

Machine guns and rifles are really infantry weapons, but anti-tank guns and anti-aircraft guns are in charge of the artillery arm, for they obviously require more specialized handling than the weapons issued on a large scale to infantry.




HOW A POSITION IS DEFENDED

Fig. 12. *This diagram shows how Bren guns are supported by heavier machine guns in the defence of any given sector of the line The rate of fire of all guns is terrific, and the cross fire set up is virtually impenetrable by unsupported infantry*

To go into action against aircraft, artillery must be very mobile, and "on the target" even at very short notice When troops are on the move or positions are being occupied by swiftly moving columns, the enemy's aircraft will do their utmost to dislocate communications and to prevent occupation. The anti-aircraft gun must be on the spot to meet these efforts and it must put up a concentrated burst of quick fire during the few moments that its target is in sight. Its manipulation must necessarily be of a different standard from that required when firing at ground targets.

GERMAN ANTI-AIRCRAFT GUNS IN ACTION

*German anti-aircraft guns make an interesting comparison with the British gun on the opposite page The Germans have experimented with projectiles like the "flaming onions," a form of chain shot*

Special mobile anti-aircraft units have been created to operate in the field, to protect communications throughout a whole theatre of war, and to safeguard moving headquarters or bases. In addition, as Great Britain herself has become the object of air attack, anti-aircraft artillery are required on an immense scale for Home Defence At first Territorial anti-aircraft units were maintained for Home Defence, but in September, 1939, further fusions took place and the role of the Territorial Army was altered and extended to meet the new conditions. Anti-aircraft searchlights, which were once operated by the Royal Engineers, and the anti-tank gunnery, formerly performed by the infantry, were taken over by the artillery. Anti-aircraft brigades are the most mobile units in the field.

The first anti-aircraft guns included a quick-firing 3-inch designed to reach effectively to heights between 8,000 and 10,000 feet, and a 2-pounder pom-pom to combat low-flying aircraft, which could fire at the rate of one hundred rounds per minute. These guns each have a crew of five and are formed into units consisting of eight guns each.

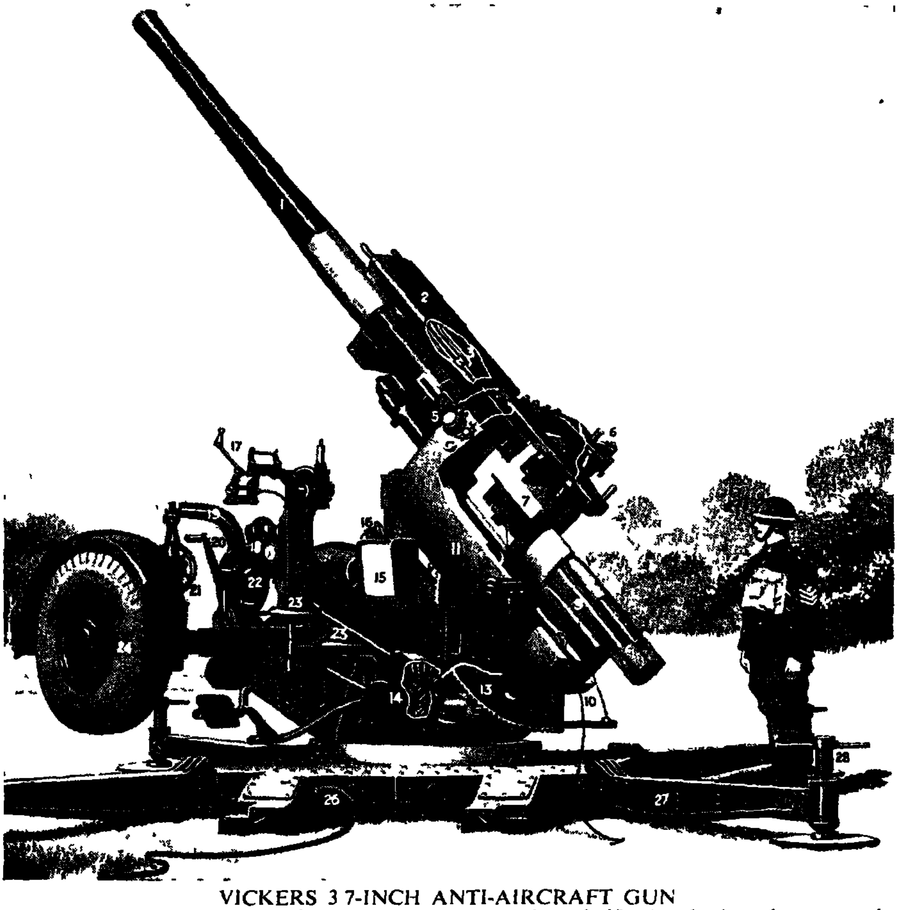
**VICKERS 3.7-INCH ANTI-AIRCRAFT GUN**

The menace of newer and faster raiders could only be met by new anti-aircraft guns such as the Vickers 4 5-inch and the 3.7-inch (Fig. 13). These guns are splendid examples of modern artillery, embodying many features of unusual interest. The shell and cartridge of the 3.7-inch weighs about half a hundredweight, yet the gun is capable of firing eight rounds per minute. Its high-explosive shell, effective up to altitudes of 40,000 feet, weighs some 28 lb , and it can destroy any aircraft that are within the range of its explosion

A valuable feature of the gun is that it

can be assembled rapidly, and the huge straddle legs that support it when in action can be packed up with it, ready to move off to a new position in a matter of minutes. The gun carries its own electrical batteries, and the dials of its instruments are illuminated so that it can be used during hours of darkness. It has a high angle of elevation and can be fired almost vertically—the firing angle is actually eighty degrees In the whole range of modern artillery there is no more remarkable weapon than this, spouting high-explosive shells to a ceiling nearly eight miles high, and fixing on its target with fatal scientific precision by an ingenious system of fire control.

This system of fire control depends on




VICKERS 3.7-INCH ANTI-AIRCRAFT GUN

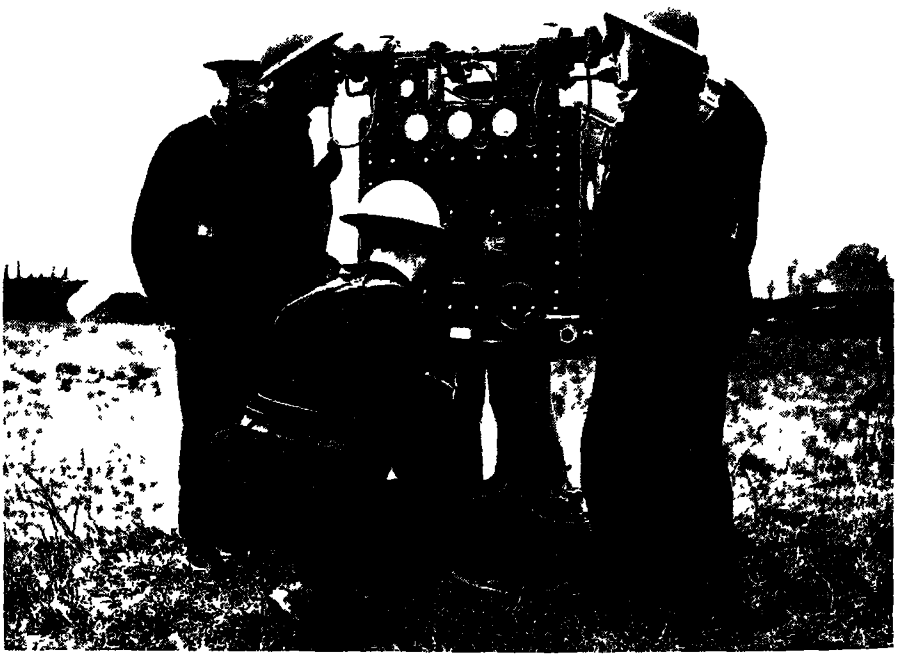
**Fig. 13.** *The shell and cartridge of this gun weighs about half a hundredweight, yet eight rounds per minute can be fired 1, Barrel 2, Recuperator 3, Recuperator piston 4, Recoil cylinder 5, Oil gauge 6, Breech pivot 7, Breech block 8, High-explosive shell 9, Loading tray 10, Cord for sliding loading tray into breech 11, Cradle 12, Trunnion 13, Elevating arc and gears 14, Gear case 15, Screen for fuse setter 16, Bearing dials. 17, Sights. 18, Elevating dials 19, Wheel davits 20, Elevating handles 21, Wheel lowering hand wheel. 22, Drift indicator 23, Seats 24, Road wheel raised 25, Turntable 26, Cable from predictor 27 Gun legs. 28, Screw adjusters*

an instrument called a predictor (Figs. 14 and 15). This instrument, which was tried out with great success in the Spanish Civil War, looks like a huge camera mounted on a tripod. As soon as the operators train the sights of the predictor on to approaching enemy aircraft the instrument automatically begins to work out the height, speed and direction of flight of the hostile machine. From these details the predictor estimates how a shell should be fired in order to hit a fast-moving target. It indicates not where the enemy *is*, but where he *will be* by the time the shell reaches him—hence the name "predictor."

An electric cable connects the predictor to the gun, and by means of indicators gives the gunlayer his aiming directions. He looks at the predictor's moving points instead of at the target and sets his gun accordingly.

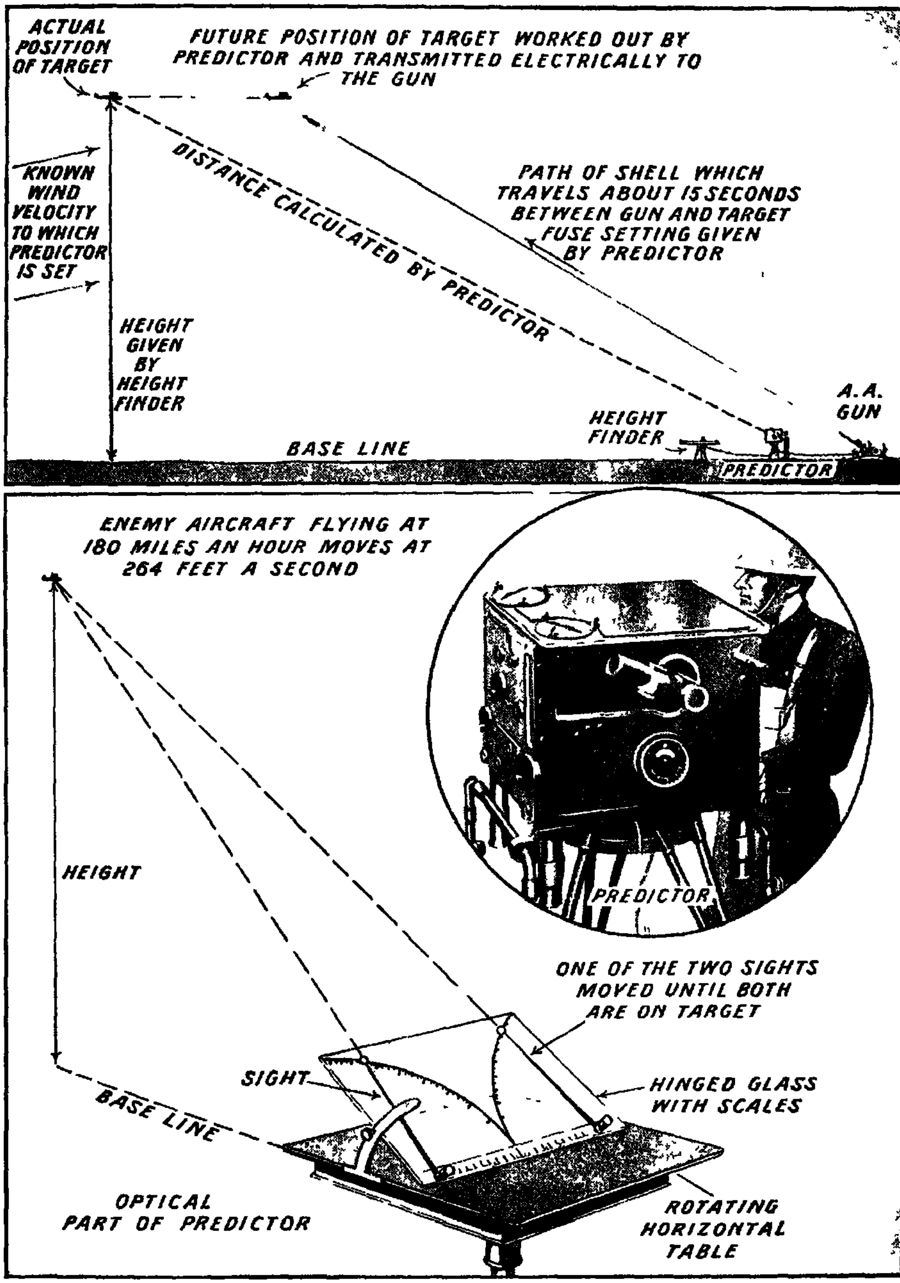
One way in which an enemy pilot can avoid being caught by this marvellous instrument is to zigzag frequently, and so follow an unpredictable course. But if the pilot does this he cannot aim his bombs or guns effectively. To drop bombs with accuracy he must steady his machine, and in doing so he allows the predictor to lay the anti-aircraft guns with uncanny and deadly accuracy.

To make the chances worse for the airman the predictors generally work in pairs to serve a battery of eight guns, four to each predictor. Each gun has a crew of ten men, and every man is detail-perfect in his own duties.



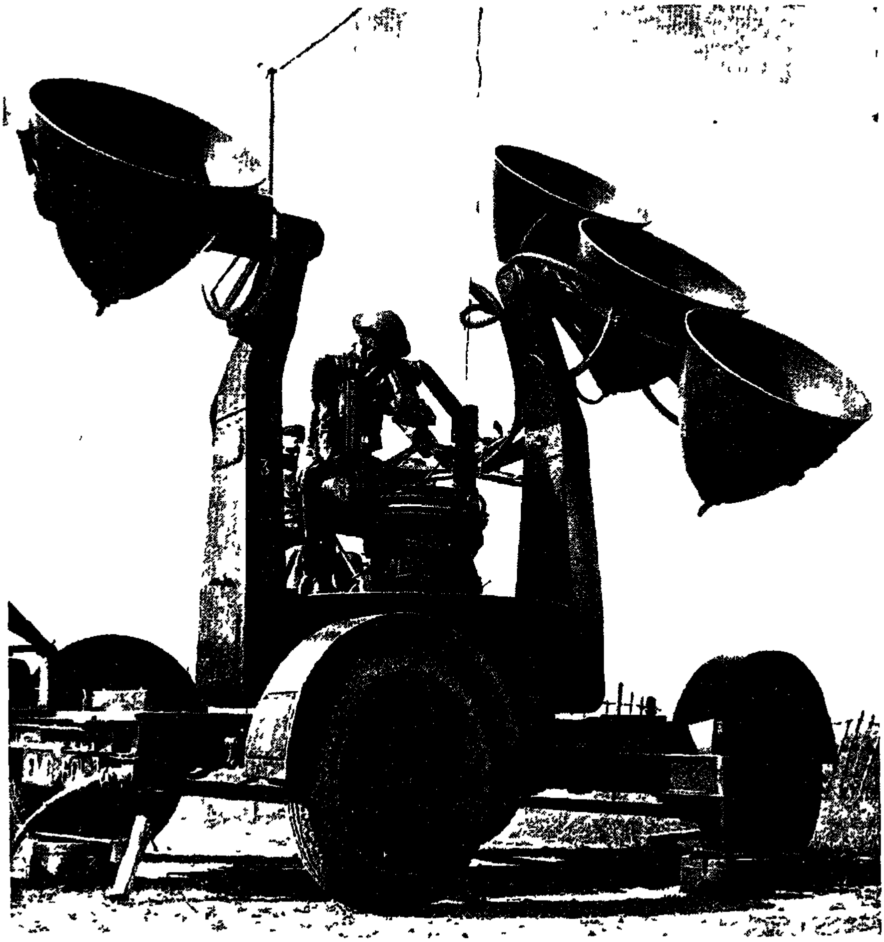
EYES OF THE ANTI-AIRCRAFT GUN—A SPERRY PREDICTOR

**Fig. 14.** *Details of this amazing instrument are given in the drawing on page 389 The introduction of this instrument into anti-aircraft batteries has greatly increased the efficiency and accuracy of these units, and made the work of the enemy bomber more hazardous*




PRINCIPLES OF WORKING OF THE PREDICTOR

**Fig. 15.** *The predictor is amazingly accurate. It transmits to the guns the speed, direction and height of an aircraft, and "predicts" where it will be when the shell reaches it.*



EARS OF THE ANTI-AIRCRAFT DEFENCES

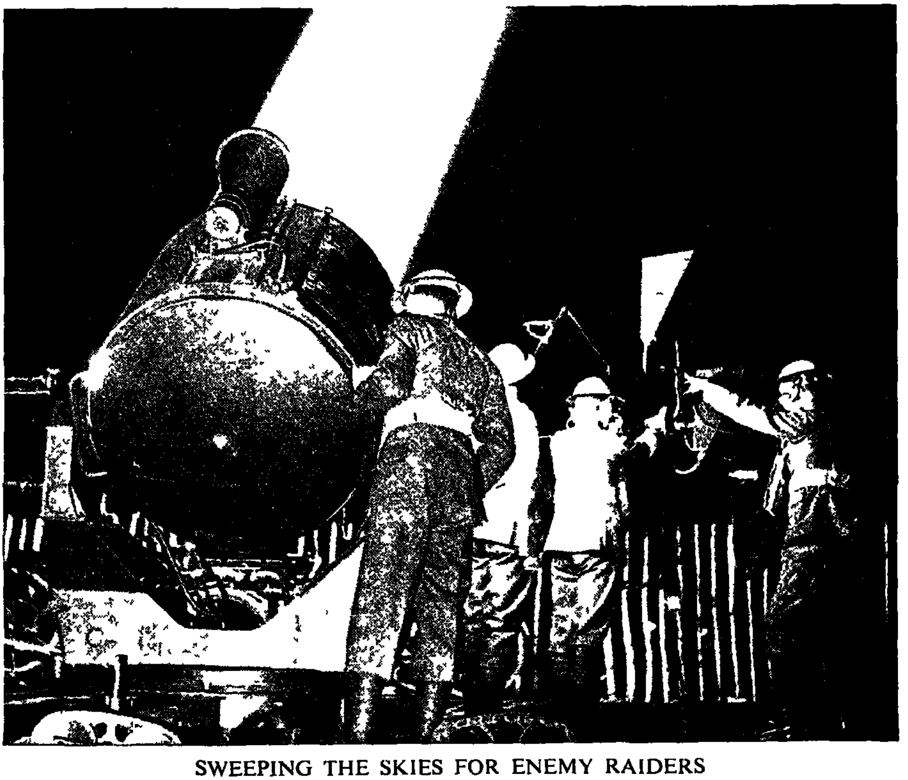
**Fig. 16.** *A mobile sound locator at work. These large cup-like objects act in a similar way to a lens, except that they deal with sound instead of light. They are, in effect, giant ear trumpets, and enable the crew to pick up the drone of approaching aircraft while still very far away, and to determine the exact point from which the sound is coming*

Another aid to anti-aircraft gunners is the sound locator (Fig. 16), the purpose of which is to determine the position of enemy aircraft from the sound of their engines. Sound locators consist of a group of bell-shaped trumpets that are, in effect, giant ear trumpets so mounted that they act somewhat similarly to a range finder (*see* page 264) except that they deal with sound instead of vision.

The locator is mounted on a mobile truck and the operator uses a stethoscope. The trumpets and the operator rotate around a common axis, the movement being under the operator's control. On the approach of enemy aircraft the operator moves the locator until the sound of the aircraft's engines is equally loud in both earpieces of the stethoscope. The trumpets of the locator are then pointing

directly toward the enemy aircraft so that its height and direction can be determined. Due allowance is made for the difference in the actual position of the aircraft and its position when the sound reaches the locator, for the aircraft is moving at a high speed while the sound is travelling to the ground. This "time lag" is due to the fact that sound takes an appreciable time to travel over a given distance. For instance, as sound travels at the rate of approximately 1,100 feet per second, it will take 13.5 seconds to travel a distance of 15,000 feet, and allowance must be made for this in the calculations sent to the guns.

Sound locators are particularly useful when the enemy aircraft fly above low-lying clouds. The predictor is useless in such circumstances, for its operators cannot see the aircraft, but the locator, which depends upon sound, will be able to discover the aircraft's position. Even if the aircraft are invisible, their position can still be indicated by searchlights working in conjunction with the locator The searchlight beams concentrate on the determined position (explained later on pages 392 and 393), the triangle formed in the clouds clearly indicating the position of the enemy aircraft to the intercepter fighters. Anti-aircraft defence at night would be useless without the searchlight, and searchlight detachments work in co-operation with all anti-aircraft guns They are used as mobile units and can



SWEEPING THE SKIES FOR ENEMY RAIDERS

*Searchlight detachments work in close collaboration with all anti-aircraft guns As soon as one searchlight picks up the enemy aircraft others concentrate on it to mark its position.*

be placed wherever needed to search the skies for enemy aeroplanes.

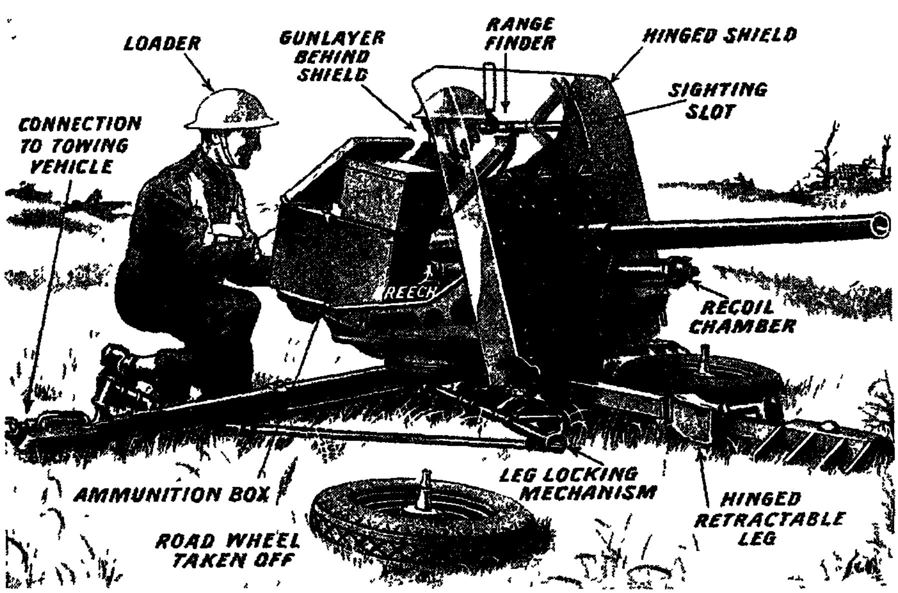
Military searchlights vary in size and type, according to requirements and conditions, but the type in general use is the 90-cm. searchlight. All types work on the same principle. Reflectors concentrate a very bright light into a parallel beam which can be turned by the operator in any direction desired.

### COOLING OF SEARCHLIGHTS

The source of light is generally an electric arc, the flame of which consists of the vapour of carbon heated into incandescence at the high temperature of 5,400° F. As the positive carbon pencil in an electric arc tends to burn unevenly, it is rotated in the searchlight by a small electric motor, whilst an electrically-driven fan keeps the lamp clear of fumes So great is the heat generated that special methods are employed to keep the searchlight cool enough to handle

The mobile searchlights used for anti-aircraft work are wonderful examples of optical perfection, and the mechanism by which they are controlled is remarkably ingenious. Once a raiding aircraft has been located and picked up by the searchlight it must be held in the beam, however often it may change direction at speeds of hundreds of miles an hour A quick touch on the controls of the searchlight must be able to swing the beam rapidly, or its fast-moving target will move out of sight.

Even in daylight a high-flying monoplane is easily lost by the naked eye, and at night the difficulty is greatly increased. Thus it can readily be understood that operating a searchlight calls for considerable skill, and the crew must know just when to expose and when to drop off the target. As soon as one searchlight picks up an enemy aircraft, two others from neighbouring detachments concentrate on it. The pyramid of light




2-POUNDER ANTI-TANK GUN IN FIRING POSITION

**Fig. 17.** *The 2-pounder anti-tank gun fires an armour-penetrating high-explosive shell When it is brought into position its wheels are detached and its three legs opened out*

MOBILE ANTI-TANK GUN AND CREW

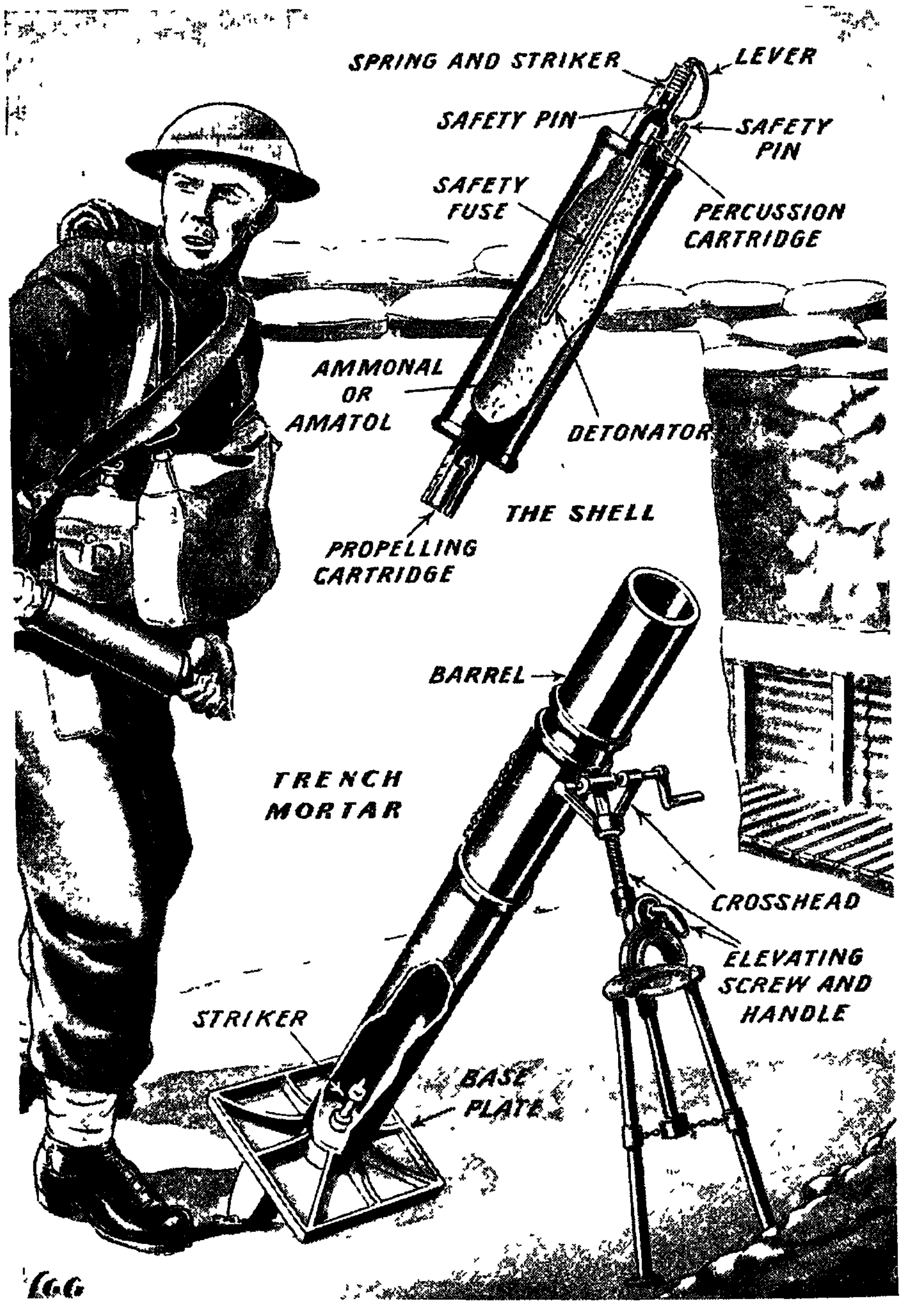
**Fig. 18.** *This latest type of anti-tank gun can be handled when necessary by two men, and has a rapid rate of fire. Notice the size of the shells carried by the soldier on the left*

thus formed signals the position of the enemy to the anti-aircraft guns or to the intercepter fighters. Great skill and co-operation are needed to "fix" a raider so that convergent searchlights change him from an unseen menace into a target for the anti-aircraft gunners

Anti-aircraft guns began to be developed during the war of 1914-18, but the anti-tank gun was developed after that war and forms the latest branch of the artillery. Like anti-aircraft guns, anti-tank guns must also be able to deal with targets that move at speed, but unlike anti-aircraft guns they are close-in fighters, firing at ranges of, perhaps, only 300 yards They are laid with open sights direct on the target itself and, as will be understood, they fire armour-piercing projectiles. Quickfirers of different sizes and patterns are employed, according to the class of tank to which they are opposed Besides being armour piercing, their shells may carry a bursting charge to explode with terrible effect in the confined spaces of a tank in action

The new .55-inch anti-tank rifle (Fig. 10) has a range about twice that of an ordinary rifle, and weighs about 37 lb. Its armour-penetrating bullets are large, and the rifle is 5 feet 4 inches long. This extreme length gives the rifle deadly accuracy in skilled hands. The magazine holds five rounds, and as the bullet can pierce light armour at distances of 500 yards or so, the rifleman has a good chance of scoring a knockout as the tank approaches. For very short distances the anti-tank rifle can be carried by one man, but normally it is transported in the rack of the platoon truck, together with 160 rounds of ammunition

Other and more powerful anti-tank guns (Figs 17 and 18) are employed by the British Army, but all work on the same principle. They must be capable of rapid fire at comparatively short range and of being aimed directly at their targets. Except when installed in permanent fortifications they are always mobile.




"DRAIN PIPE' THAT SPOUTS DEATH—THE TRENCH MORTAR

**Fig. 19.** *The trench mortar is designed to lob high-explosive projectiles over the parapet of a trench into the enemy lines It has a range of about 1,000 yards.*

We have already referred to trench mortars. These are powerful weapons when used at fairly close quarters, despite their deceitfully simple appearance (Fig 19). Their long and wide muzzles have led them to be called "drain pipes" and the peculiarly shaped shells of some types have suggested the nickname "toffee apples." Trench mortars play an important part in the equipment of the modern army.

For trench warfare a simple base plate with two uprights is all that is necessary to hold the squat muzzle of the mortar, which tilts up at an angle of about forty-five degrees. As the range is never great —perhaps 1,000 yards—the barrel of the mortar is not rifled, and its huge projectile is simply lobbed over to the enemy's position.

The flight of the mortar's shell is easily visible, and until the highest point is reached the nose may be uppermost When the missile flattens out before falling, there is a characteristic waggle as the weight tips forward and brings the nose into position. The explosion, which is caused by a percussion fuse, is a very heavy one.

### USES OF TRENCH MORTAR

The 3-inch mortar, which fires shells nicknamed "jam pots" from their shape, has many uses in attack and defence It has an effective range of some 1,500 yards and fires a 10-lb. high-explosive shell. Easy to load and essentially simple, the mortar has a rapid rate of fire. It can fire as many as forty rounds per minute, and consequently to supply it with ammunition is obviously a difficult problem. Small supply tanks are used to transport it, and infantrymen can carry the shells in special holders

In attack the mortars are used to break down barbed-wire entanglements or to dislodge an enemy from trenches and machine gun posts. Although the shells have not sufficient penetrative power to destroy solid buildings, they can break down roofs and burst behind walls with devastating effect Mortars are small enough and portable enough to be useful as quick support to the rifle battalions. They can fire smoke shells as well as high-explosive shells, and since the shells they fire are large for the size of gun, they can quickly put up a very effective smoke screen. In defence, the mortars co-operate closely with machine guns to cover the withdrawal of the rearguard

### GRENADES AND BOMBS

The rifle grenade is smaller and less powerful than the mortar shell, but is used in much the same way

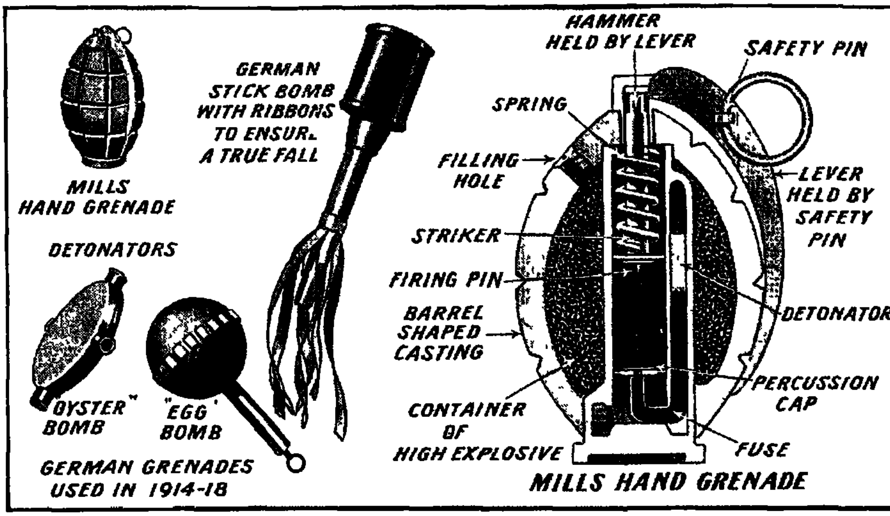
Grenades are generally thrown by hand and infantrymen are given special instruction in bombing. They are however, frequently fired by a discharger cup attached to a rifle. In this way the range is increased to a maximum of 200 yards. A special high-explosive cartridge forms the charge with which the grenade is projected.

Rifle grenades are rarely used in the open Their main purposes are to drive an enemy from hasty cover, to assist in trench raids, or to dislodge snipers from shell craters

### THE MILLS BOMB

The hand grenade is, of course, an old weapon that has found modern uses, and its name gave the Grenadiers their title in the seventeenth century. The modern hand grenade is the outcome of experience with the Mills bomb that was used extensively in the war of 1914-18. It proved to be a formidable key with which to open enemy trenches, for an expert bomber can hurl it for a distance of about thirty yards.

The Mills bomb (Fig 20) is oval in shape and weighs about $1\frac{1}{2}$ lb. Outside its cast-iron case is a spring lever held by




MILLS BOMB AND ITS GERMAN COUNTERPARTS

Fig. 20. *The Mills bomb is the modern form of hand grenade Its fuse is ignited when the lever on the right-hand side springs free, as the bomb leaves the thrower's hand Considerable skill in timing is required on the part of the thrower.*

a pin that keeps the bomb in the safety condition. When the bomber is ready to throw, he withdraws the pin, but holds the spring down by the grip of his hand until he releases it by throwing the bomb. Freed from restraint the spring then releases a striker which ignites the fuse. The fuse burns for a few seconds and then fires the detonator which in turn fires the main charge of explosive. As the detonator's charge can be heard exploding just before the main report, this type of bomb has a characteristic "crish-crash" explosion. It was proved in the Spanish Civil War that the Mills bomb can be used with success against light tanks

### UNUSUAL TYPES OF SHELL

Many unusual types of shell are used by modern artillery. Smoke shells are used to conceal troop movements, and star shells to reveal enemy movements at night Gas shells and smoke shells have instantaneous fuses, but the star and some high-explosive shells work on time fuses. Thermite or incendiary shells are used for setting buildings alight.

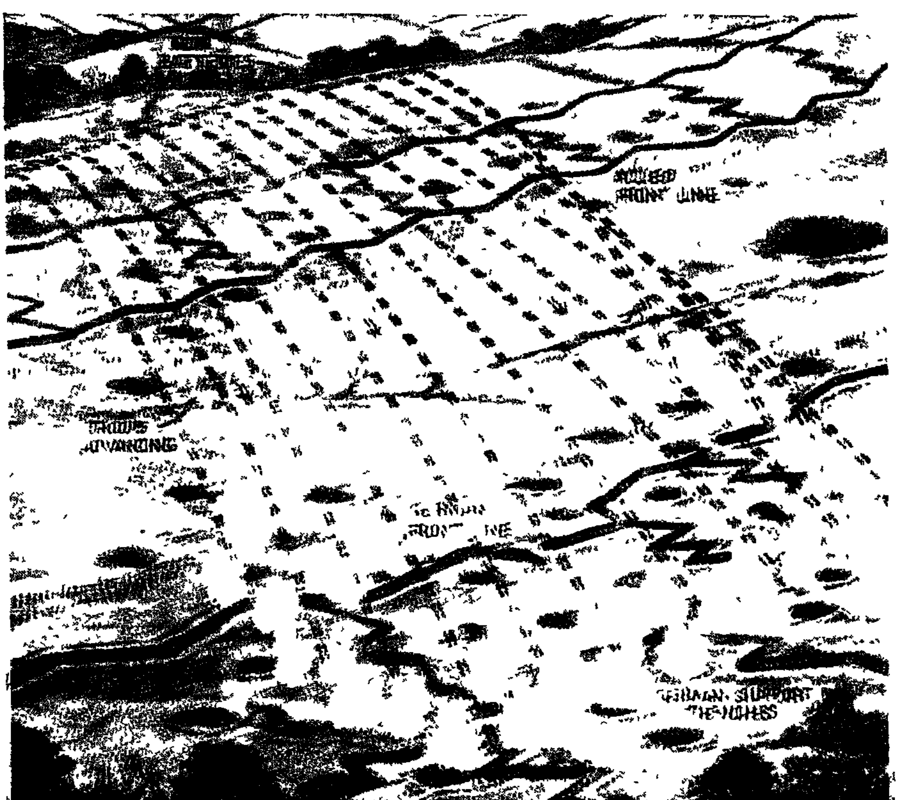
Not only does modern artillery use a diversity of projectiles, but it also uses different methods of firing. An attack requires covering fire, to silence enemy machine guns, mortars, and other weapons; and also close support fire to engage unexpected targets as they appear. Before an attack there will be an intensive artillery preparation to deal with the enemy position, to destroy the barbed wire defences in "no-man's-land," and to destroy as far as possible machine gun posts and advanced positions.

The artillery also put down barrages. These may be either on the enemy front-line positions before attack, the barrage being "lifted" to the second line or beyond at the moment the attack takes place, or in the form of "box barrages" (Fig. 21) by which attacking troops are isolated and cut off from reinforcements whilst they are counter attacked or otherwise dealt with by the defenders. Barrages naturally call for very accurate

ranging, timing, and laying of the guns.

Another type of fire is "counter-battery." The guns engaged in this work seek to destroy hostile artillery in which effort they are greatly assisted by aircraft co-operation (*see* pages 129 and 130). In counter-battery work the position of the enemy guns must be discovered, and one method employed to do this is called sound ranging. This method depends on the fact that sound takes an appreciable time to travel given distance, as already explained in connexion with the [illegible].

In sound ranging three microphones may be used, placed, perhaps [illegible] apart. Fig. 22 shows an aerial view of an area in which the opposing forces may be assumed to be operating, the inset A being a map of the same area. When the enemy gun, hidden in the trees in the bottom "left-hand" corner of the illustration, is fired the sound vibration of the discharge reaches the microphones 1, 2 and 3 across the river, and the resulting currents are registered at a central observing station behind, where they actuate delicate galvanometers or registering instruments. From the needle of each galvanometer a spot of light is reflected on to a [illegible] sensitive photographic




HOW A BOX BARRAGE IS MADE

*Fig. 21. Striking effect of a box barrage. This system of the concentrated [illegible] field guns isolates a section of the enemy's line so that reinforcements cannot be brought up to resist an attack. Both flanks are also shelled to cut off reinforcement from right or left*

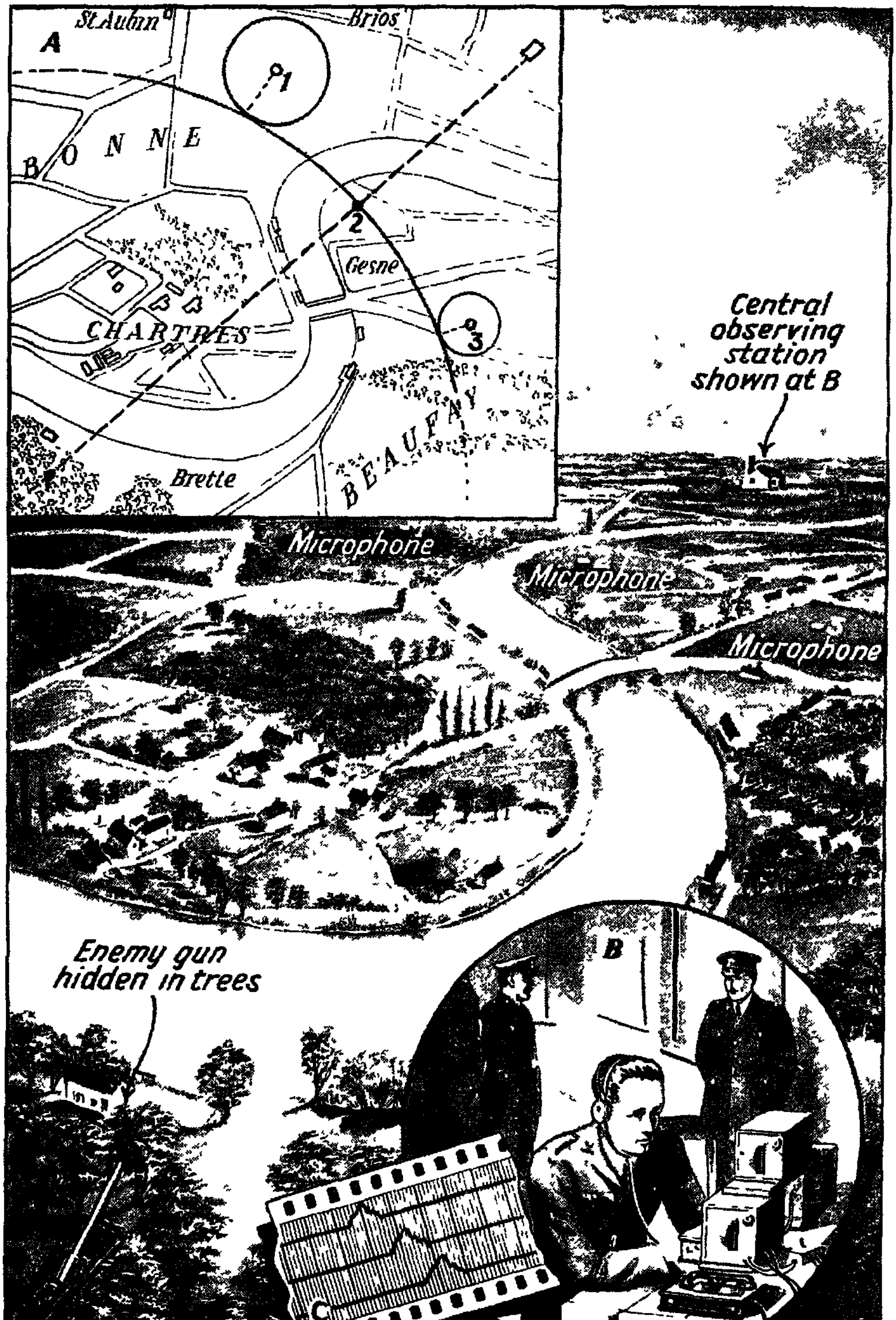



**Fig. 22.** *Details of the method of sound ranging as used in this diagram are give on page 397*


HEAVY ARTILLERY DEFENDS BRITAIN'S COASTS

*Britain's first line of defence against invasion is her Navy, but batteries of heavy guns like this one, manned by the Royal Artillery, form her second line*

film mounted on a rotating drum. Time signals are also recorded on the film alongside the light spot traced by the needles of the galvanometers. Due to the varying distance from the source of the sound, the microphones record the passing of the sound wave at slightly different times, as shown at C, Fig. 22. By comparing the differences in these times, the position of the enemy gun can be ascertained. This information is then communicated to the artillery who proceed to "search" for the target in order that the enemy gun may be silenced and put out of action.

In these and innumerable other ways the work of the artillery is continually changing. It has become highly scientific and complex, but it still calls for those qualities of initiative, endurance and courage that have always been associated with the artillerymen.

(French Official Photograph

LIGHT AND SHADOW IN THE DEPTHS OF THE MAGINOT LINE

*A sense of grim, ghostly efficiency pervades this dramatic study of a well-guarded corridor in the ammunition section of the Maginot Line Notice the light railway lines*

## CHAPTER XIV

# DEFENCE SYSTEMS IN WARFARE

STRETCHING for hundreds of miles along the frontiers of Europe are vast defensive systems, almost invisible, to bear the brunt of armed invasion. They are the latest answer of the mechanized age to the devastating machinery of military attack. Never have frontier fortifications been so well hidden, so closely linked, so planned for death, as these mighty systems of defence. They are magnificent examples of engineering embodying miracles of detailed design. They are all the more awe-inspiring because the secret of their real strength can only be wrested from them by wholesale slaughter. Fig. 1 gives position and extent of Maginot and Siegfried Lines.

Before we review the reasons for their strength, we must remember that such systems are not the whole art of defence. In its modern form defence begins with the individual soldier's "tin hat" and other methods of personal protection, and extends through every phase of military endeavour Vast concrete labyrinths, such as the Maginot and Siegfried Lines, where thousands of men keep ceaseless vigil, are restricted to frontiers. In the event of a break through, other defensive measures would have to bear the brunt of an attack.

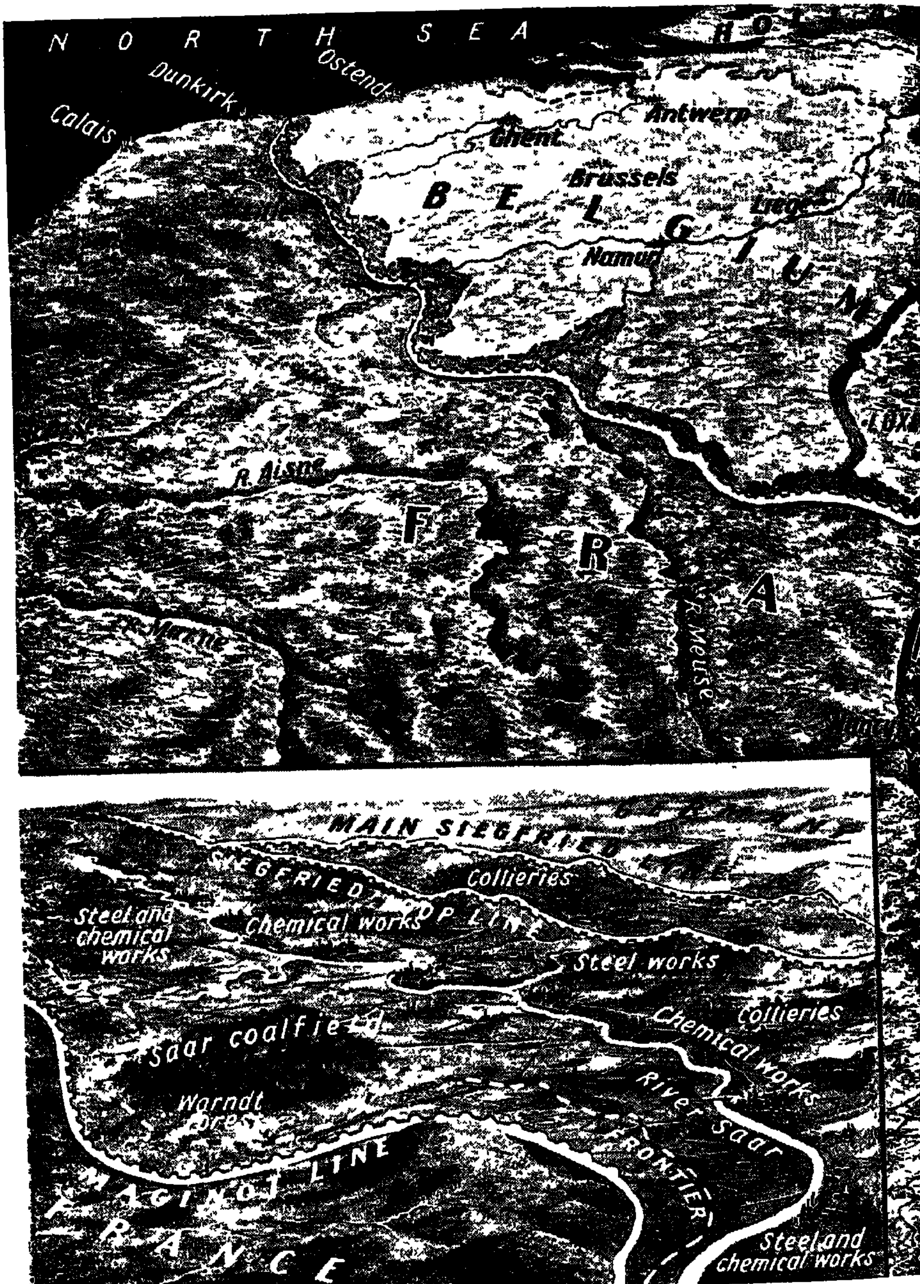
### TYPES OF BODY ARMOUR

In studying the art of defence we shall repeatedly find that the best solutions to the problems provided are only modernized revivals of ancient defensive methods Thus, defensive armour, which came into wide use during the war of 1914-18 in the form of steel helmets and breast plates, recapitulates the Middle Ages. And, similarly, hidden in the heart of the Maginot Line are modern editions of ancient forts that have been built over time and again as the art of defensive fortification developed. It will be seen, then, that the underlying principles of defence have always been the same, and are merely adapted to counter each new weapon of attack.

### STEEL HELMETS

The most familiar form of protective armour, the "tin hat," was designed in 1915. It quickly proved its value in action, and rapidly overcame the many prejudices against it. Ease of manufacture was one of its valuable features, for its shallow dome could be stamped out in a single operation without unduly thinning the metal of the crown, and its brim was wide enough to protect the face from flying shell splinters and shrapnel. The British helmet proved far more resistant than the corresponding French one. Made of high-percentage manganese steel, the tin hat would resist, with remarkable uniformity, pistol bullets travelling at the rate of 600 foot-seconds. Such a missile produced a deep indentation but did not break through. Moreover, when a projectile, fired at greater velocities pierced the helmet no splintering or shattering occurred to aggravate the seriousness of any resulting abrasion or wound.

The German Army also adopted a steel helmet, of somewhat different shape, but the Germans were more inclined to favour the breast plate idea Their breast




TWO VAST CONCRETE FRONTIERS—THE

**Fig. 1.** *This artist's impression (which must not be regarded as accurate in detail) indicates the shape and extent of the Maginot and Siegfried Lines, the two principal European*


MAGINOT AND SIEGFRIED DEFENCE SYSTEMS

*defence systems Both these systems were developed from the original vision of a wounded poilu, Sergeant Maginot, who based his conception on the traditional line of armed forts.*

plates and thigh pieces were designed for the use of sentinels, garrisons of shell holes, men in listening posts, and for machine gun teams lying in the open. Although this armour impeded movement, it considerably reduced casualties during a heavy bombardment.

### GERMAN BREAST PLATES

The standard German outfit consisted of four plates, the uppermost attached to the shoulders and the others hanging below. The top plate, 18½ inches in height, followed the shape of the chest, its upper border being rolled outwards to protect the throat. A riveted shoulder plate, bending backwards, served as a hook over each shoulder. There were three abdominal plates, which together formed the apron. The three plates were each about six inches in depth, but they tapered in width. The smallest—what the Scots would call the sporran plate—was at the bottom, and was almost flat, the others being shaped to the body. To enable the wearer to move in silence, the plates were hung on heavy webbing and well padded with cow-hair felt.

Body armour, however well designed it may be, is only a secondary means of defence, for even the unarmoured soldier is comparatively safe from artillery attack if he is securely entrenched. Before a war of movement has settled down into a war of position, the entrenching tool is the key to protection. It was the hurriedly-constructed trenches of 1914 and onwards that broke the surge of battle and became the "front line"—synonym of heroic endeavour.

Words such as "trench" and "line" suggest a clear-cut cleavage, but in that respect they are misleading. The front line has always been a series of lines, purposely irregular, so that none can be enfiladed for long distances by gunfire operating from the flanks. Trenches twist and turn to face different directions, taking any advantages of local cover that the ground affords.

The first hastily-dug defences are improved as far as possible New communication and support trenches are constantly being prepared and perfected. Dugouts for underground headquarters, casualty stations, and similar purposes are needed for the infantry who are manning the line

Earthworks and shelters of all types stretch out far behind. In front a similar —if less extensive—process begins, as snipers and sentries creep out to favourable positions. Minor adjustments are always being made, trenches are widened, deepened and shortened to suit the changing needs. In addition to the trenches themselves, barbed wire entanglements, which form the terrible obstacles of no-man's-land, are also erected for defence (Fig. 2).

These numerous extensions, before and behind the lines, are accompanied by operations in the air above it, and by tunnelling in the ground below. The continuous aerial and artillery activity may restrict movement above ground during the day, but below the surface mining and sapping may go forward At the same time listening posts are installed to discover what the enemy sappers are doing At points that are particularly vulnerable or important, the back areas are quickly strengthened by more permanent fortifications. Thus, pill boxes and similar erections tend to cluster and crouch behind the lines of trenches, and extend the first hasty excavations into a more permanent defensive system, cleverly and cunningly concealed

### EFFECT OF THE MACHINE GUN

It was the invention of the machine gun that dictated the adoption of this class of warfare, instead of the war of movement. Describing the entrenchments of 1914, Captain Liddell Hart

NAZIS BUILD WIRE FENCE ALONG DUTCH FRONTIER

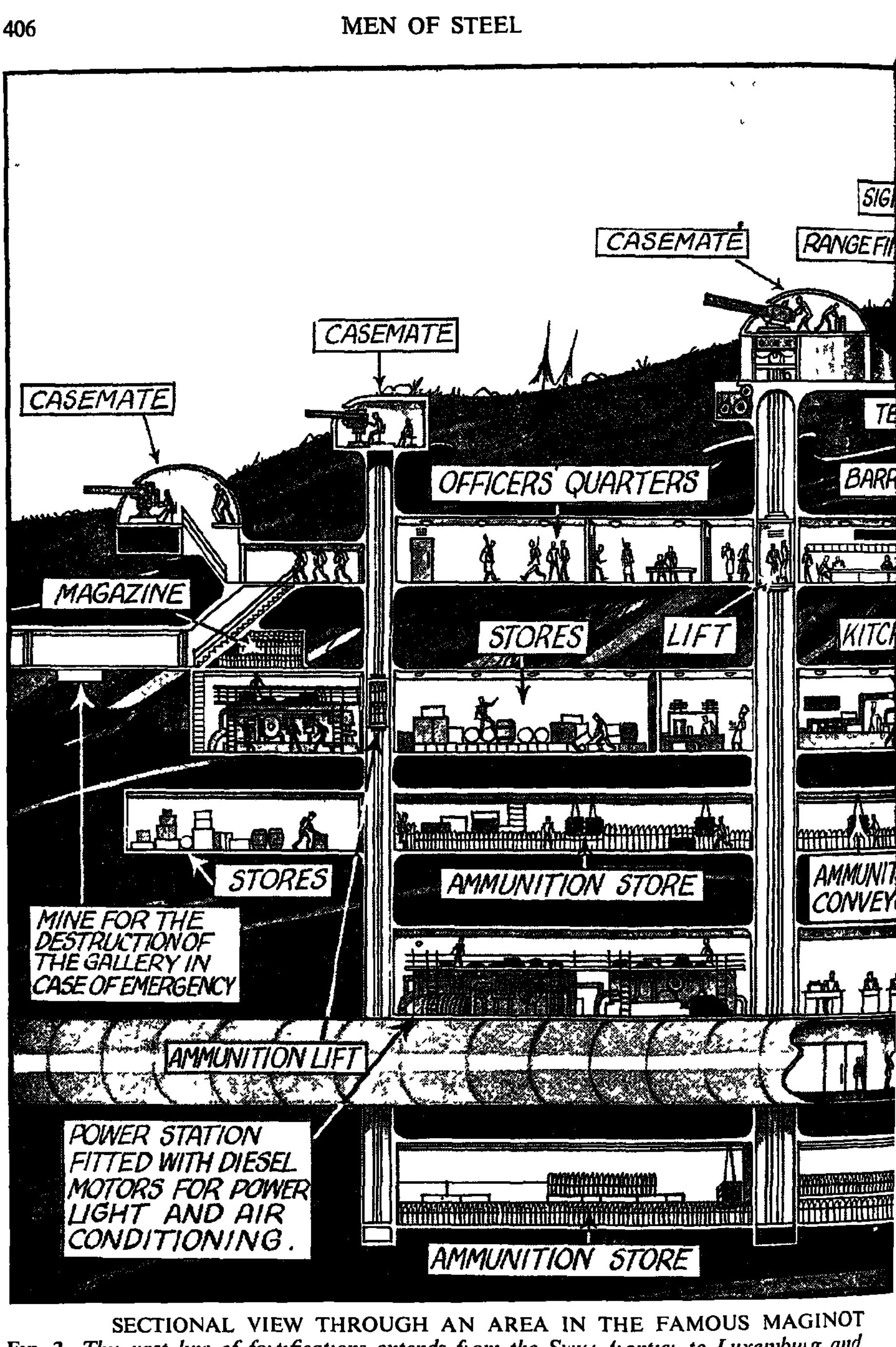
**Fig. 2.** *Early in 1940 the Germans began strengthening their position on the Dutch frontier This German picture, intended to suggest purely defensive preparations, shows barbed wire entanglements being erected As all old soldiers know, barbed wire in no-man's-land makes a terrifying obstacle*

wrote, "the armies were held fast in the grip of Hiram Maxim. The history of the years that followed is one of ceaselessly renewed frontal onslaughts on entrenched lines, held in reality by machine guns if nominally by infantry. . . . There were two possible methods of reviving movement on the battlefield. One was to make men bulletproof by putting them in armoured vehicles. The other was to teach men to evade bullets by a revival of stalking methods. The British were the pioneers of the first, the Germans of the second method."

The British tanks and the infiltration tactics of the Germans have already been mentioned in preceding chapters. To counter them an entirely new defence system has been evolved, capable of withstanding attacks by massed tanks or by infiltration, however far those methods might be developed and exploited It was the genius of a wounded Frenchman, Sergeant Maginot, which solved the problem. The Maginot Line is the greatest modern defence system. Its only rival in the same class, the Siegfried Line facing it, is admittedly based upon the French prototype. Sergeant Maginot was badly wounded in November, 1914, and, as he lay in hospital, he conceived the idea of an impregnable line of fortresses that would protect his country from German attack He devoted the rest of his life to shaping and perfecting this vision.

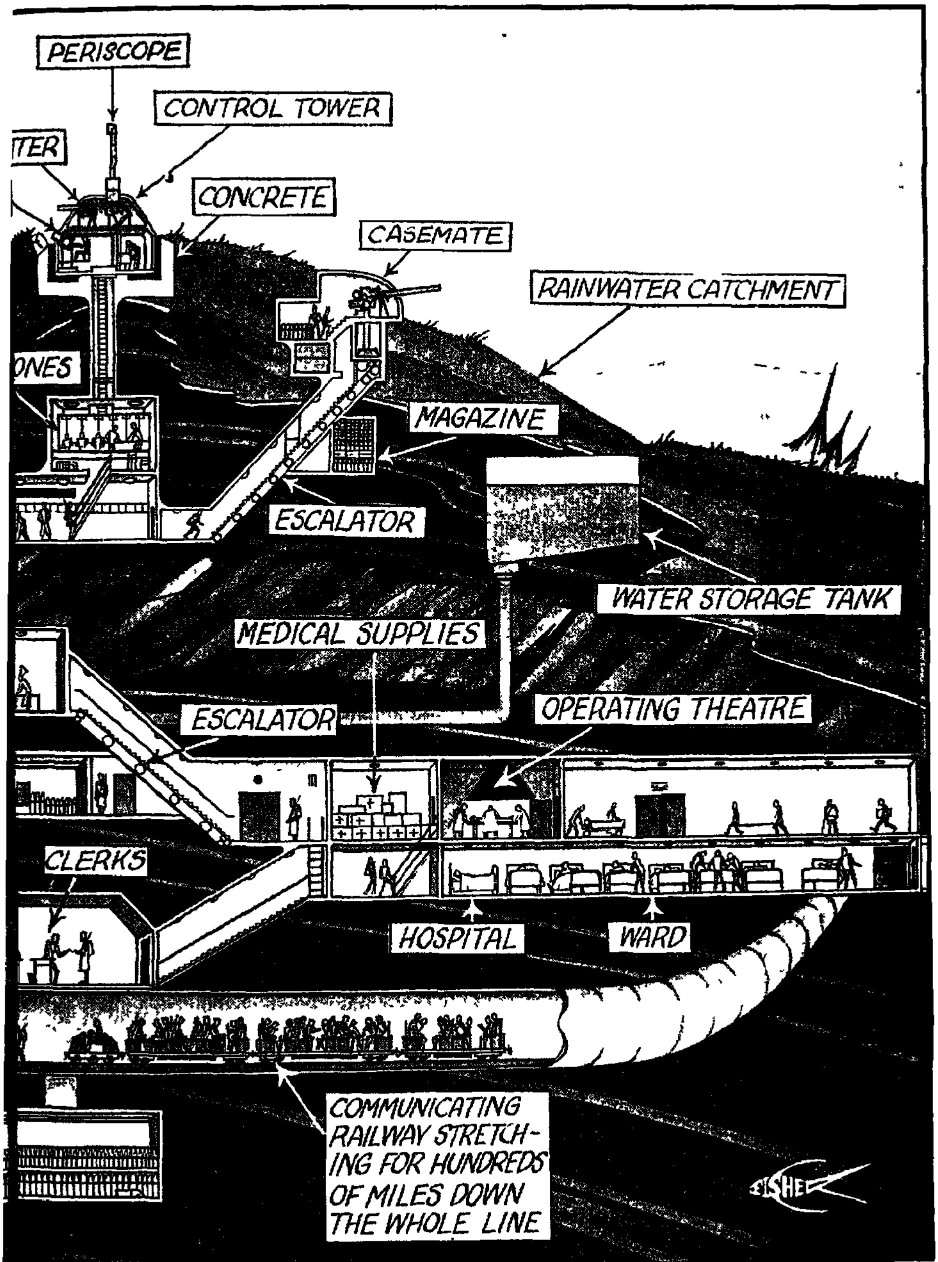
### MAGINOT'S MASTERPIECE

He became a politician, and for many years tried to convince his countrymen that his scheme was practical. In 1929, when he became Minister of War for the second time, work on the first section of




SECTIONAL VIEW THROUGH AN AREA IN THE FAMOUS MAGINOT

**Fig. 3.** *This vast line of fortifications extends from the Swiss frontier to Luxemburg and thence along the Belgian frontier to the North Sea The section shown above is further protected by advance fortifications of barbed wire entanglements, infantry and tank traps,*




LINE, A MODERN MIRACLE OF ENGINEERING CONSTRUCTION
*and a series of pill-box machine and anti-tank gun posts Every fort is a self-contained unit capable of prolonged independent resistance. The whole line is gasproof, and its concrete defences are strong enough to resist the explosion of three large shells on any one point*

the line was commenced. By 1934 the original scheme was completed, and Sergeant Maginot, who died in 1932, did not live to see his brilliant conception prove its worth in warfare; but he had the satisfaction of seeing his country adopt his scheme, and of hearing it acclaimed as a major bulwark against aggression, comparable with the French Army itself. No soldier could wish for greater or more deserved praise.

### PURPOSE OF THE FRENCH LINE

Maginot's vision was realistic and practical. He based his new conception on the old line of forts and blockhouses, developing it logically from experience in the trenches. Broadly speaking, the Maginot Line was planned to fulfil a threefold purpose.—

(*a*) To discourage a German invasion of France altogether, or to make it too costly to be worth the attempt.

(*b*) If such an invasion were attempted, to hold it in check long enough for France to mobilize her army and to protect her industrial centres from paralysis

(*c*) To effect a great reinforcement of French man power by supplying in advance every possible protection for her defenders, thus countering Germany's numerical superiority.

To fulfil these fundamental requirements, Maginot foresaw a gigantic co-ordinated defence system, much as it exists today. In emergency its sections could be manned immediately by local troops, whose homes lay in the shelter of the forts they manned (Fig. 3).

There was genius in the conception of the basic idea. There was an equal wealth of engineering skill in the execution of its detail. The chain of forts and blockhouses developed into a wide belt, linked together for mutual support. Their fields of fire form a continuous and overlapping curtain of death along the whole French frontier from Luxemburg to Switzerland.

We know now that Maginot's hope of discouraging a surprise attack on France (as in 1914) was justified. Germany did not attempt the lightning land stroke after the outbreak of war in September, 1939. The French Army was able to mobilize behind its new barrier, and French industry was not disorganized. Maginot's "shock-absorber" theory had proved correct.

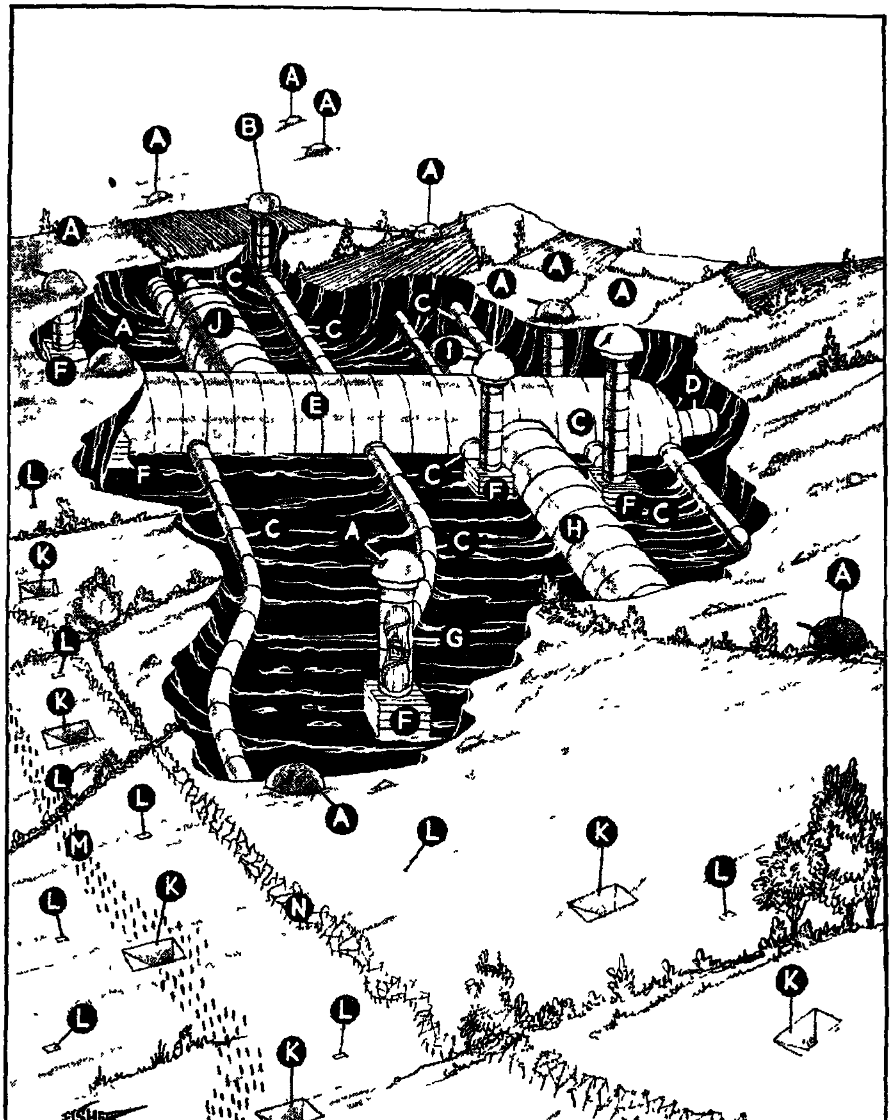
Why did Germany fail to attack, as she had done in 1914? The reasons that are given below seem more than sufficient to hold back even the most determined enemy.

By erecting the Maginot Line, France chose her own fighting positions and prepared them in advance. Every frontier hill, plain and valley was surveyed to gauge its exact military value in all contingencies. As a result of these surveys the line of defence took shape along the best available natural barriers.

### USE OF NATURAL OBSTACLES

Carefully hidden artillery was installed wherever the contours were favourable. Every hill was utilized, and walls of fire commanded its approaches. Every promising elevation suitable for an observation post was considered. Those chosen were prepared, wired and camouflaged, so that nothing in the area could move without detection. The defensive properties of hollows and valleys were exploited just as thoroughly as those of the higher ground. Plans were prepared for extensive flooding, to hold up the advance of tanks. In some places water could be diverted from adjacent rivers or canals; in others artificial reservoirs were built.

Steep declivities were noted with a view to enlargement; and any variation of land level was treated as a possible asset, to be embodied in the scheme if



WAR BENEATH THE EARTH—THE MAGINOT LINE

**Fig. 4.** *Section of the famous fortifications.* (A) *Casemate (armed)* (B) *Observation post* (C) *Communicating galleries* (D) *Inclined gallery leading to main entrance* (E) *Main gallery* (F) *Armoured posts at base of casemate shafts* (G) *Casemate shafts equipped with lifts and staircases* (H) *Magazine* (I) *Control room* (J) *Kitchens and living quarters* (K) *Concrete tank traps (these are covered over with brushwood to avoid detection, and are shown uncovered in the diagram for the sake of clarity)* (L) *Land mines* (M) *Anti-tank railfields* (N) *Barbed wire Advanced listening posts communicate with all forts*

[French Official Photographs

FRANCE'S SURE SHIELD—THE MAGINOT LINE

Fig. 5. *An underground maze of corridors, railways and magazines, the Maginot Line has much in common with the battleship in design, for, like the battleship, most of the activity goes on below. Above are shown* (A) *Changing guard* (B) *A food train moving up* (C) *A gun casemate* (D) *Gun crew in a casemate* (E) *In the magazine*

needed. Special attention was given to ditches, and those already existing were incorporated in the general scheme, or supplemented by new ones in carefully chosen positions. In some places deep ditches were hidden below shallow water, to lure tank crews to destruction. The defensive value of woods, clumps of trees, commons, plantations and shrubberies, were all appreciated In some districts there was planting, in others clearing—it was all part of the system that was to save the soil of France.

In this way the chief natural features of the frontier formed a backbone of inherent strength and the defenders secured two valuable assets—they selected the positions that were naturally best suited to their purpose, and they fortified them as required before the attack began.

When every advantage offered by low-lying ground or rising ground had been taken, there remained the problem of making the intervening level countryside impassable Artillery ranges were worked out in great detail, and forts and blockhouses were co-ordinated. Preparations were made to put down a dead-stop curtain of fire over the threatened areas The field of fire from every armoured turret in the forts was scaled on gridded maps, so that it could quickly be concentrated on any single spot Strung out between the forts were the lines of blockhouses, or casemates, where a dozen men, armed with machine guns and anti-tank artillery, could hold out for days, even if isolated from the other defenders.

### LINKING OF BLOCKHOUSES

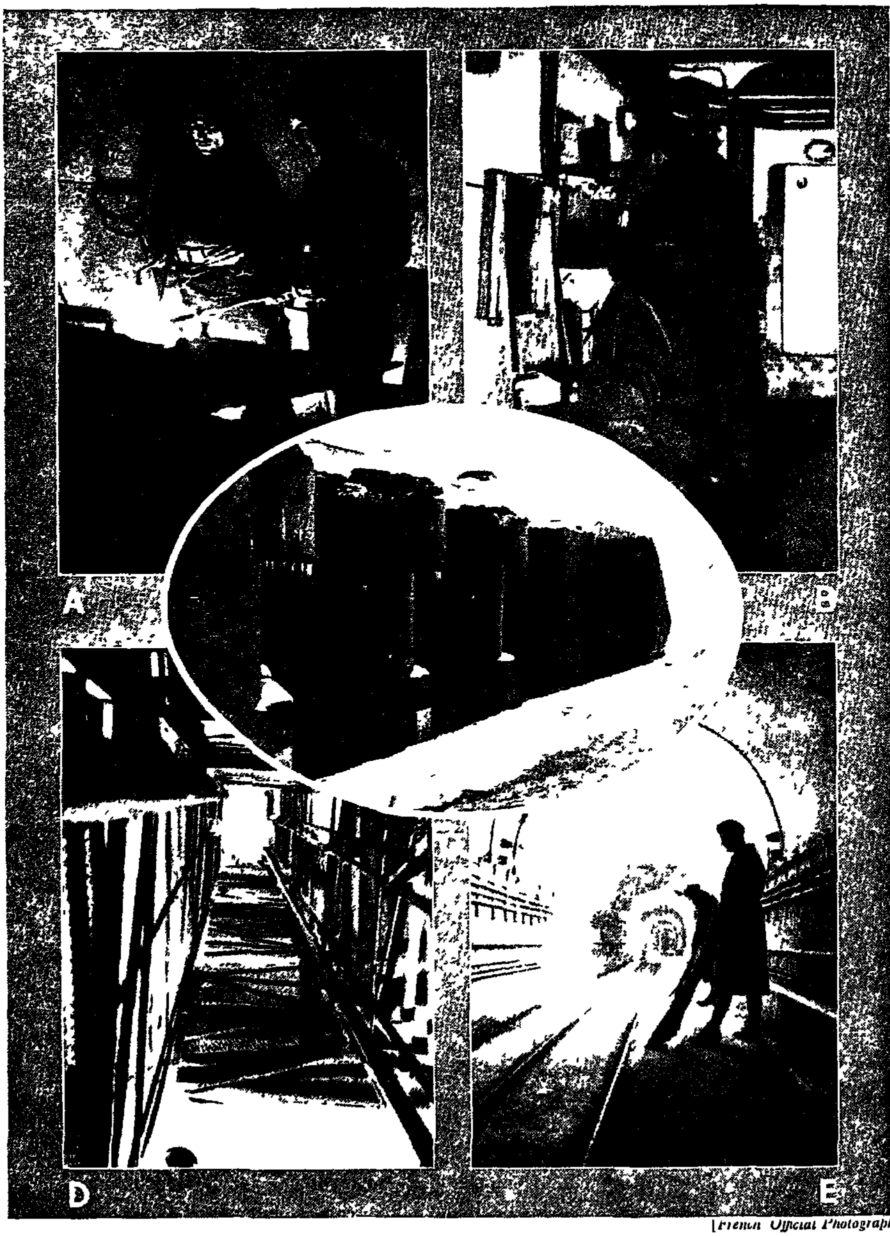
To enable some of the garrison to rest while the others manned the guns, deep shelters of concrete, well separated from the casemates, were provided Usually the casemate was concealed on one slope of the hill, and the shelter on the reverse slope Linked by covered passages and fully stocked with ammunition and food, each blockhouse was in itself a formidable obstacle to any advance. But in co-operation with other carefully-sited blockhouses it became part of a barrier likely to daunt even the most desperate assailant (Fig. 4)

Concealed trenches, along which men and supplies could pass in safety, connected the outposts with their supports. Strong redoubts were embodied at frequent intervals to enable the garrisons to withstand shell fire

### USE OF CONCRETE AND STEEL

Since earthworks crumble under continuous bombardment and tend to collapse through the action of water, the trenches were reinforced with concrete. The parapets, instead of being sandbagged as in the war of 1914-18, were also made of concrete Embrasures were installed in the parapets where necessary. Some were cast in the concrete itself, in other places they were made of steel, with armour-plated doors swinging on hinges. As a final precaution, the trenches were made so that they could be flooded if the defenders were driven out General views of the line are shown in Figs. 5 and 6

When enough had been done to make it impossible for troops advancing along even the most favourable routes to capture the positions, steps were taken to make the approaches themselves impregnable Barbed wire entanglements, supported on iron pickets firmly embedded in concrete blocks, were arranged in squares At all the corners and in the centre of every square the pickets held up a formidable tangle of barbed wire, spreading out in all directions like brambles. Cross lacings of barbed wire destroyed any chance of methodical demolishment by hand, and created an impenetrable maze These deadly snares could be extended as far as necessary by the addition of extra squares of wire.




[French Official Photographs

UNDERWORLD CITY—INSIDE THE MAGINOT LINE

Fig. 6. *A modern wonder of organization as well as construction, the famous Maginot Line embraces almost as many activities as a complete city Above are seen* (A) *Oxy-acetylene welders at work* (B) *Testing hand grenades and automatic guns, notice the characteristic Maginot Line uniform.* (C) *Armed casemate* (D) *Worm's-eye view of a lift shaft* (E) *Sweeping the great communication galleries*

THE WEST WALL—HITLER'S REPLY TO MAGINOT

**Fig. 7.** *The West Wall, better known as the Siegfried Line, is a more elastic system of fortifications than its French counterpart It is based on mobility of counter attack rather than on a line of fortresses* (A) *Shutting a bombproof door* (B) *German soldiers emerging* (C) *Air-protection tower* (D) *Camouflaged blockhouse* (E) *Advanced machine gun post*

Land mines and tank traps were installed to prevent tanks crushing down these entanglements. These tank obstacles took various forms, the commonest being a belt of steel rails of different lengths jutting out of the ground at various angles. Enormously strong, these rails penetrate the armour of approaching tanks Their sharp points can also damage the tracks of these machines, and so hold the tank immobilized where the artillery can destroy it. To increase their danger, the snares were concealed from attackers by long grass and undergrowth (*See* Figs. 8 and 9)

### THE MAGINOT FORTS

Overruling the whole scheme of fortification were the forts themselves. They were designed to hold the key positions and to act as the bases on which all the other means of defence depend Marvels of ingenuity were exploited in their construction and the facts about them which have already been disclosed are fascinating. Before we examine them, however, we must consider why reliance has been placed on fortifications of this type, after the lesson of 1914. It was then proved that modern siege artillery could demolish the most carefully prepared positions, as demonstrated on the Belgian frontier at Liège and other places. But these instances do not tell the whole story

Acting on the assumption that forts had proved inferior to trenches, the French abandoned some of their Verdun fortresses and removed the guns. Fort Vaux and Fort Douaumont were captured by the Germans and used to shelter their troops against the heavy French counter bombardment This was in 1917, and eight months later the French recaptured the fortresses Knowing how heavy the counter bombardment had been, they were surprised to find that none of the armoured gun turrets were destroyed, and most of the concrete shelters were perfectly sound. Because of what they found, they investigated anew.

Delayed-action shells and aerial bombs, which penetrate fairly easily into earth, were found to be comparatively powerless against thick concrete defences Heavy howitzer fire was then concentrated to test the materials, and it was found possible to arrange for cover which would withstand the effects of three successive shells striking in exactly the same place. The penetrative power of even the latest type of shell could not render a position untenable if it was protected by thick enough layers of concrete and armour plate. This lesson was exploited in building the Maginot Line

The thickness of the concrete used in the Maginot Line varied, according to need, but where heavy bombardment was expected a layer at least ten feet in thickness was used. The strength of the armour plating required was estimated with similar liberality. Once committed to concrete and armour plating, the French General Staff exploited their defensive advantages to the full They established a network of undergound galleries, some of which lie hundreds of feet below the surface. Here the power plant and magazines are safe. In the heart of this labyrinth a miniature railway system of 60 cm. (nearly twenty-four inches) gauge was installed to serve the guns above and the men who were to man them (Figs 5 and 6)

### UNDERGROUND POWER STATIONS

Huge Diesel-driven generators supply the electrical power for operating lifts and transporting ammunition It was also planned to swing the gun turrets and fire the guns by electricity All the forts use electricity for lighting and ventilation, and there are many auxiliary demands upon the power supply


MAKING IT DIFFICULT FOR THE TANKS

**Fig. 8.** *Assault upon modern fortifications has been rendered so hazardous that only by the use of tanks is it at all practicable. To counter attacks various obstacles have been devised, the most usual being numbers of steel posts set in reinforced concrete, popularly known as "asparagus beds," designed to tear the tractors off the vehicle, and tank pits covered by brushwood. The above illustrations of these obstructions are self-explanatory.*

Fire was one danger that had to be guarded against. The fact that most of the line was sunk beneath the ground and protected by steel and concrete made it proof against incendiary attack, but the great risk might come from fires starting inside the line. For this reason no wood was used, even for tables or chairs; and all bedding and other furnishings were made of fire-resisting materials

### ANTI-GAS PRECAUTIONS

Not only had the Maginot Line to be protected against shells, bombs and fire, but also against poison gas. To seal up every crevice and opening in such a vast chain of fortresses seemed a formidable task, but a characteristic touch of genius provided the solution. Filtered and conditioned air is supplied by fans to the whole line and the atmospheric pressure inside the defensive system is kept slightly above that outside it Thus through all vents and doorways the air inside tends to leak out, and the outside atmosphere, no matter how gas laden, can never penetrate to the Maginot Line.

Communication between forts, blockhouses and outposts set another engineering problem and many methods were employed to solve it. Some of the outposts are best served by carrier pigeon, while others use semaphore or other visual methods; wireless is also used, but within the line itself the forts communicate with each other by telephone.

When the Maginot Line was built, every precaution was taken to safeguard communications. The main telephone exchanges were placed at great depths, often 150 feet below the surface. The telephone lines between the forts were duplicated and were never protected by less than twenty feet of concrete. Speaking tubes were used for short-distance communication.

The general arrangement of intercommunicating fortresses has been aptly likened to that of a line of moored battle ships in action. Each group of gun turrets and casemates under a single command has its own complete organization —control room, telephone switchboard, hospital and operating theatre, kitchens, stores and power supply. All the different sections are welded together as one co-ordinated unit, supported by similar fighting units on either side. Even if one complete unit should fall to enemy attack, the others can fight on.

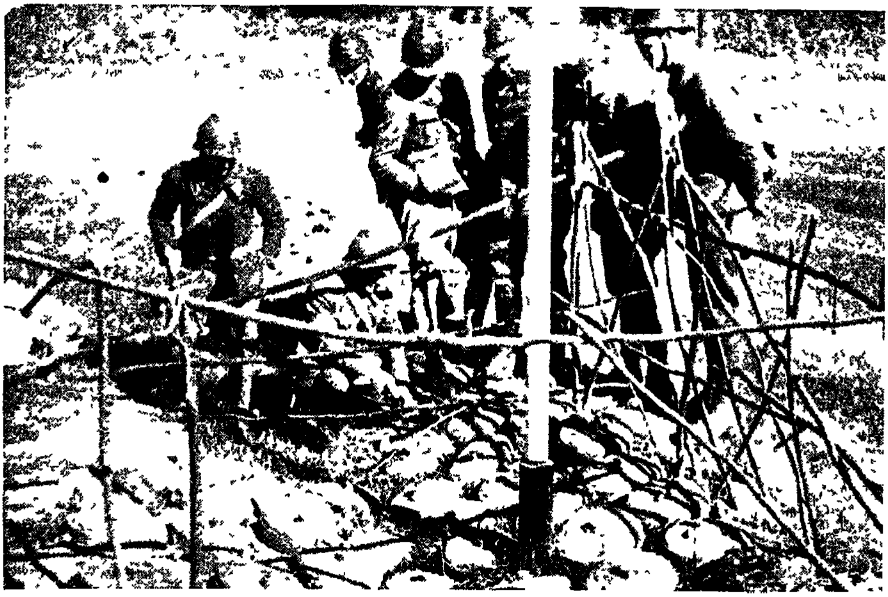
To strengthen the similarity wit ship in action there are fireproof and attack-proof bulkheads that can be shut and held against a partly-successful enemy. The armour-plated doors are covered by interior guns, so that it would be necessary to capture one underground stronghold after another before a whole fort could be taken. Even then success at one point would not cause the collapse of the defence along the whole line of battle.

It will be seen that each fort, while forming part of the general defensive scheme, is capable of acting independently. In the control room, where reports come in continually from the observation posts and where the whole attack can be seen developing, the counter measures are decided upon. The fortress can then go into the necessary action with terrifying efficiency.

### FIRE CONTROL ARRANGEMENTS

Far below, the ammunition rumbles along the galleries to the lifts. Inside the giant armoured turrets the gunners load, lay and fire their guns as directed by the indicators. Higher up, in a specially armoured shell-proof chamber is the fire-control officer. He decides the range and directs the fire of the turret below, watching its effects through a special panoramic telescope built into the armour plating.

Despite the self-sufficiency of the fort, contact with the outside world can



GERMANS LAID THESE LAND MINES

**Fig. 9.** *French troops are seen here examining unexploded land mines left by the Germans when they abandoned territory in face of the French advance in September, 1939*

always be maintained. The defenders are assured of their ammunition and food, their necessary rest periods are arranged for, and reinforcements, if desperately needed, are always available.

The importance of the Maginot Line in the defence of France entitles its regular garrison to wear distinctive uniform, the units bearing territorial names instead of numbers. On their khaki berets the personnel wear a badge representing a concrete casement on a field of barbed wire In normal times their fifteen days duty in the Line alternates with fifteen days of rest in billets.

The Maginot Line represents the modern defence system in its most perfected form. It is a coat of mail that France herself wears proudly It was born in a hospital, of a vision that possessed Sergeant Maginot, a victim of the old trench warfare. Maginot was a compatriot of Vauban and other world-famous organizers of military defence His particular genius lay in his power of visualizing the whole balanced scheme, from one end of the frontier to the other. He maintained that vision perfectly proportioned while projecting his vital imagination into its separate details.

Facing the Maginot Line is the German Siegfried Line (Fig. 7), also based on experience gained in the war of 1914-18. The Germans do not call this vast defensive system a line, but a "position." It was planned by Dr. Todt, the German Government's chief adviser on roads and fortifications, in accordance with modern German theories of military defence These theories demand outposts to delay an enemy advance in its initial stages. The outposts are not meant to be held at all costs, but are withdrawn as the attack gains momentum Behind the outposts lies a strongly fortified area which bears the main brunt

of the attack. Behind this area, out of range of the enemy artillery and safe from the enemy tanks, are the mobilized counter-attack divisions. As soon as the attackers have exhausted themselves on the outposts and the main fortified area the counter-attack divisions can be brought into action and sweep the enemy back to their own lines.

The Siegfried Line, therefore, is really a fortified strip of territory on the German frontier, in places fifteen miles deep. Its defence is more elastic than the Maginot Line because it is based on the mobile counter attack rather than on a line of immensely strong fortresses

### OTHER DEFENCE SYSTEMS

Although modern systems of defence may vary, their purpose remains the same. No military engineer would claim that he could build an impregnable fort or a line. He merely plans to delay and exhaust the attacking force so that it can be destroyed by gunfire or by a counter attack. The line he plans will vary according to local geographical conditions, the size of the defending army and the nature of its equipment Finland's Mannerheim Line was able to hold up Russia's vast army for several months because it occupied a narrow front on which only a few divisions could be deployed, and because of its great depth The Dutch defences make full use of the fact that the country is low-lying and can be flooded The security of Belgium depends partly on flood defences and partly on strongly fortified positions in hilly country

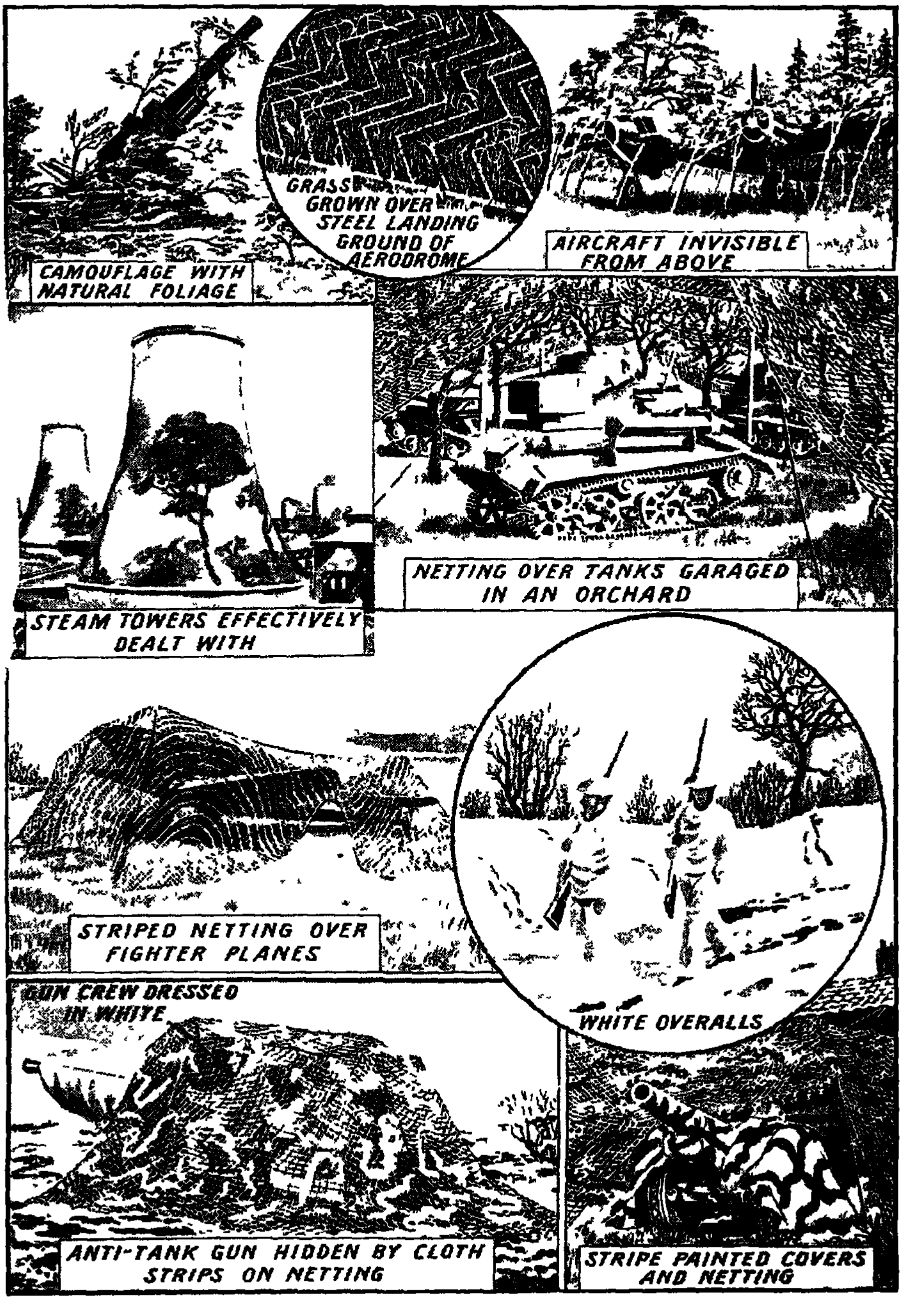
Floods can provide an effective barrier to the tank, and often low-lying country cannot be defended in any other way. Flooding is sometimes designed not so much as a direct defence as to compel all attacking movements to advance along one line rather than another, the chosen line being a heavily prepared defensive position. Amongst the methods of countering resistance by means of flooding which have been evolved is the amphibian tank. In theory this tank can cross both land and water, but its success is still questionable.

Defence systems like the Maginot Line can be adapted to suit any locality. An interesting example is the Southern Maginot Line which stretches from the coast of Africa to the mountains o Tunisia For about thirty miles it is a underground fortress of steel and con crete, housing an army, but the whol system extends over the desert for fiv hundred miles. It is based on a chain ( forts, each linked with the others, whi being at the same time capable of existin independently Many of the forts a isolated and these are provided wi sufficient supplies of ammunition, foo and water to enable them to withstand long siege. Their situation preclude attack by heavy artillery, for it is almos impossible to bring the biggest guns fa enough into the desert to attack them, but the forts must be prepared to withstand continuous bombing from the air

### METHODS OF ASSAULT

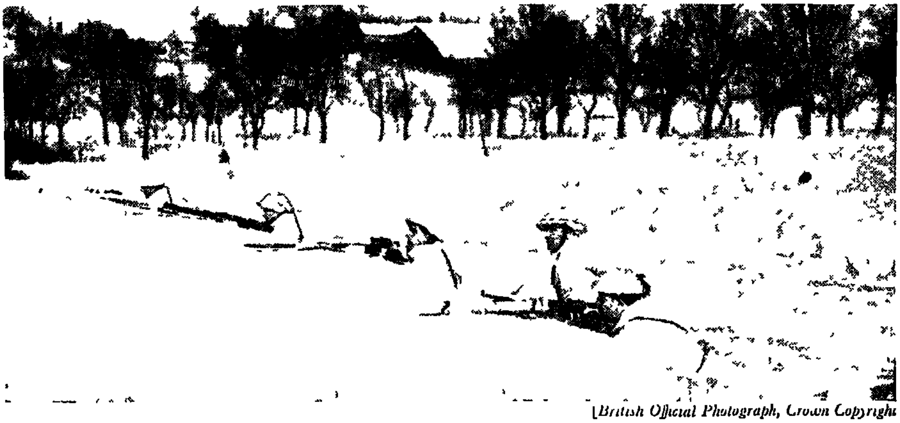
We have now reviewed the more important general features of modern defence. We have seen how permanent steel and concrete fortifications have tended to embody older forms of protection, combining them in situations where the chief and unalterable features of the countryside assist defence. We may now consider what counter measures have any hope of success.

Although the concrete and steel of the Maginot Line was made strong enough to withstand bombardment by the most powerful guns in existence, scientists are always searching for new and more effective explosives. It is always possible that a way of battering down the most formidable defences will be discovered




MODERN METHODS OF CAMOUFLAGE

**Fig. 10.** *Camouflage, the art of concealment by imitation, is a highly effective measure of defence, and has been particularly developed since the advent of the aircraft*



[British Official Photograph, Crown Copyright

HUMAN CHAMELEONS

**Fig. 11.** *British troops lining a sunken roadway in France wearing white suits, which make them almost invisible against the snow Even their rifles are bound with white material*

Tanks will always take a large part in any assault on strongly-fortified positions. We have already mentioned that tank traps form a part of most permanent fortifications. In addition, land mines are placed in front of the fortifications When mines are heavily concentrated in minefields they can be destroyed by land minesweepers before an attack opens on the main position. The land mines used to defend a sudden gap, however, would be more widely spread and so less easily detected by the enemy

### CAMOUFLAGE IN WAR

We have still to consider camouflage. This device (already mentioned in passing in Chapter V) is one of the most effective and certainly one of the most interesting of all defence measures. It is used, above all, to defeat the menace of the reconnoitring aeroplane

Modern camouflage is highly scientific and has many applications. Its uses range from the white coats that hide the movements of troops on snow, to the coloured concrete of forts, buried deep, but liable to have hundreds of tons of covering earth blown away. The coloured concrete would then remain relatively invisible

Camouflage is the art of concealment by imitation A screen of leafy branches may protect a gun, by making it invisible to the enemy, better than a huge concrete shelter. Army lorries, cars and other vehicles are provided with large nets on which branches, bushes and grass can be fixed, so that when the vehicle is backed into a hedgerow it fits perfectly into the landscape and escapes detection

Imitative concealment is also obtained in bullet-proof tree stumps, bushes or boulders for use as observation posts, snipers' positions, and machine gun sites. Although there is great scope for ingenuity in this branch of camouflage, the aerial camera is so good at spotting fakes that make-up of this kind becomes a battle of wits The simpler and bolder disguises are often better than the more elaborate.

Another branch of camouflage is line breaking and line making Because the aerial camera is so perfectly adapted to reconnaissance, roads and tracks have to be camouflaged carefully. For example, as mentioned in an earlier chapter, the concrete runways of an aerodrome have to be coloured and shaded to blend in with the flying field. Similarly, the best

concealed gun position is useless if the tracks of its crew across the field converge upon it, and suggest that it is a centre of activity.

Where the formation of tracks is unavoidable they are often continued by camouflaged "extensions" to a neighbouring road, so that the whole path appears to be a harmless route.

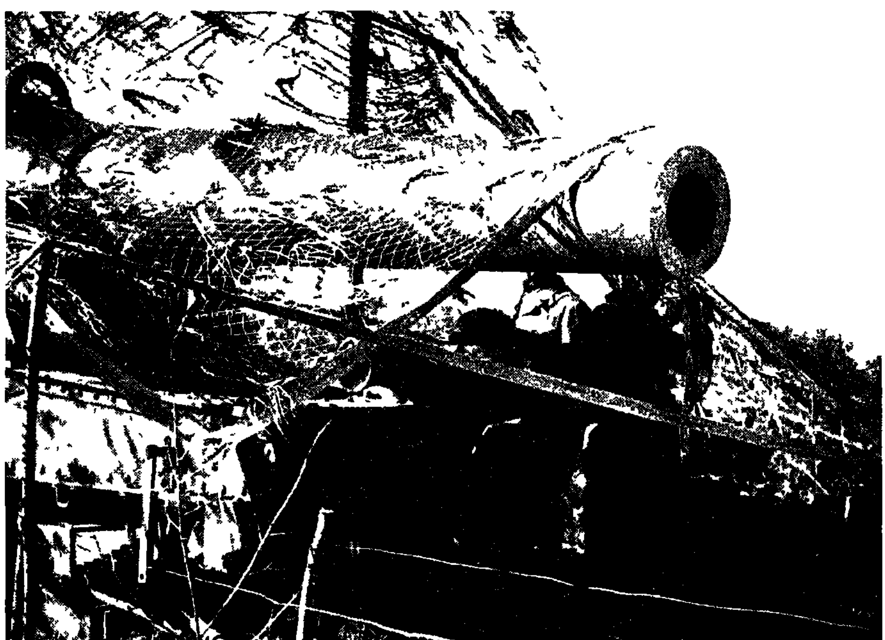
Line breaking is the type of camouflage required by large buildings, the mere size of which would attract suspicion. Carefully planned splashes of colour, at regular intervals, can suggest shadows, and break up a large roof so that it looks like a row of harmless cottages.

Often a confused medley of light and shade will split up an object's visibility quite effectively, though the dazzling contrasts might seem to make it more conspicuous than before Shadows are one of the great difficulties, for aerial photographers will cross early in the morning, at midday, and late afternoon, so that their photographs by recording the movement of shadows will show what really lies below

### VALUE OF DUMMY TARGETS

The expert in camouflage uses his blacks and whites lavishly, to offset this kind of repeated observation But it is astonishing how informative the latest types of aerial photographs can be when a series of photographs of the same position are taken at different times of the day

Yet another form of camouflage is the provision of dummy targets. A load of bombs dropped on a "town" which is really strings of dimmed street lamps in



*French Official Photograph*

HIDDEN FROM THE AIRMAN'S VIEW

**Fig. 12.** *Netting is extensively used for purposes of camouflage in modern warfare The heavy French gun shown here is safely hidden from the curious eyes of enemy aircraft.*

| *Group* | *Gas* | *Persistence* | *Smell* | *Physical and Chemical Properties* |
|---|---|---|---|---|
| Tear Gas | C A P (Chlor-aceto-phenone) | Non-persistent | Faintly of floor polish | White crystalline solid vaporized when heated |
| Tear Gas | K S K (Ethyl-iodo-acetate) | Persistent | Peardrops or cellulose acetate | Brown oily liquid in commercial form |
| Tear Gas | B B C (Bromo-benzyl-cyanide) | Persistent | Watercress | Brown oily liquid |
| Nose Irritant | D A (Di-phenyl-chlor-arsine)<br>D M (Di-phenyl-amine-chlor-arsine)<br>D C (Di-phenyl-cyano-arsine) | Non-persistent | None | Arsenical crystalline solids which when heated give off an odourless and invisible smoke |
| Lung Irritant | Chlorine | Non-persistent | Chloride of lime (bleaching powder) | A gas, greenish colour at point of liberation, soluble in water Rots clothing and corrodes metal |
| Lung Irritant | Phosgene | Non-persistent | Musty hay or rotten potatoes | Invisible except possibly whitish cloud at point of release or in presence of moisture Corrodes metals Rendered less effective by rain |
| Blood Irritant | Arsine (Arseniuretted hydrogen) | Non-persistent when used as gas | Faintly garlic in high concentrations | Invisible in its gaseous form In powder form is a greyish white substance (calcium arsenide) resembling calcium carbide |
| Blister (Vesicants) | Mustard gas (Di-chloro-di-ethyl sulphide) | Persistent | Faint mustard, onions, garlic or horse-radish | A heavy oily liquid almost colourless in the pure state, but a dark brown colour in the commercial state Readily soluble in fats and spirits Liquid and vapour both very dangerous although liquid more so than vapour Has high boiling point (217° C), and low freezing point (6° C), therefore very stable Less than 1% soluble in cold water, hot water is more rapid Difficult to detect owing to slight smell which is easily masked by other smells |
| Blister (Vesicants) | Lewisite (Chloro-vinyl-di-chlor-arsine) | Persistent | Strongly and pungently of geraniums | A heavy colourless oily liquid containing arsenic Rapidly destroyed by water at any temperature High boiling point (190° C) and low freezing point (–5° C) |

CLASSIFICATION OF WAR GASES PHYSICAL AND CHEMICAL

**Fig. 13.** *War gases fall under two main headings, persistent and non-persistent The former are generally liquids, whilst the latter are true gases or poisonous smokes These are sub-*

| *Effects* | *Necessary Protection* |
|---|---|
| Immediate pain in eyes, copious flow of tears, spasms of eyelids and irritation of shaved skin | Respirator affords complete protection |
| As above—and in high concentrations is a respiratory irritant | As above |
| As for K S K | As above |
| Slightly delayed (0–5 minutes) causing sneezing, burning pain in chest, nose, throat and mouth Also mental depression Symptoms may increase after removal to pure air or after donning respirator | As above |
| Immediate and progressive effects causing burning sensation in eyes, nose and throat Extreme irritation of breathing passages and lungs Possibly lethal due to damage to lungs | As above |
| Eight to ten times more deadly than chlorine, being a severe lung irritant but less irritant to eyes, throat and nose Also tear gas Delayed action | As above |
| Violent vomiting Causes blood poisoning | As above |
| Has a delayed action wherein lies its greatest danger The presence of mustard vapour in low concentrations may pass unnoticed until damage has been done Mustard liquid or vapour will rapidly damage the eyes, lungs and exposed parts of the body the eyes being particularly vulnerable, becoming severely inflamed and causing loss of sight in severe cases, particularly after liquid in the eyes if not removed promptly Effects on lungs would cause loss of voice and coughing after exposure, possibly progressing to bronchitis, etc, up to twenty-four hours later with perhaps fatal results Either liquid or vapour will have no immediate effect on the skin, but after two to twenty-four hours, swelling and blistering may appear Stomach or intestines will be severely damaged by swallowing contaminated food or liquid | Respirator for eyes and lungs Anti-gas (protective) clothing for skin |
| Immediate effects by severe irritation of nose, causing either immediate wearing of respirator or withdrawal from atmosphere Liquid in eyes will cause immediate and permanent injury, and on skin will cause stinging within one minute Redness and blistering follow much quicker than mustard gas Blister will contain an arsenical fluid which must be medically evacuated Vapour on the skin is less effective than mustard vapour | As above |

PROPERTIES, EFFECTS, AND MEANS OF IDENTIFICATION
*divided according to their effects on the body into tear gases, nose and lung irritants and blister gases This table gives the main characteristics of most gases likely to be used in warfare.*

open country is a load of bombs lost to the enemy. Similarly, false "guns" can be displayed, but they must be cleverly half-camouflaged or the enemy will guess that their visibility is not accidental (Figs. 10, 11 and 12)

## POISON GAS IN WARFARE

We have already mentioned the ingenious way in which the Maginot Line is protected from gas attack Gas, however, can cause great damage to troops behind the line and to civilians Gas attacks can be delivered in several ways Gas shells can be fired from guns, gas bombs may be dropped from aeroplanes or fired from special mortars, gas may even be sprayed from aeroplanes or released from cylinders whence it is carried by the wind over enemy positions Few gases are likely to prove lethal except in high concentration, which seldom can occur in the open air, but in low concentrations they can temporarily incapacitate large bodies of men As such, they may rob troops of their powers of defence or destroy civilian morale

The gas used in modern warfare is often carried in liquid form When sprayed from an aircraft it can be spread over a wide area, or it can be dropped in many small bombs The effectiveness of a gas attack depends largely on weather conditions, and atmospheric temperature also has a direct effect on all known war gases As certain gases are very light they are useless if a wind is blowing, for they will be dispersed or blown away from the intended target Also, temperature conditions may lift the lighter gases to a height above the ground where they will cause no damage

An ideal day for a gas attack would be one of those often met with during a typical English autumn when one gets mild, calm weather and perhaps a light breeze of over five miles, but under twelve miles per hour. Under such conditions the gases might be kept near the ground with sufficient wind to spread them effectively.

The temperature of the atmosphere generally decreases with the height above ground level, a condition known as "temperature lapse." As warm air has a tendency to rise, such conditions, with warm air slowly rising, would merely tend to draw the gas away from ground level

There are two exceptions to the above conditions At dawn and at dusk the temperature remains more or less constant with increase in height, giving rise to a condition known as "zero temperature gradient" On clear nights, and occasionally by day, it is sometimes found that the temperature increases instead of decreasing with height above ground level. This condition, called "temperature inversion," is the most favourable one for the release of gas, for the cooler air tends to flow downwards and helps to keep the gas at ground level.

## CLASSIFICATION OF GASES

War gases may be divided into two main groups, termed "persistent" and "non-persistent." Generally speaking, the former are in liquid form, giving off a vapour and the latter are true gases or poisonous smokes They are generally classified according to the effects they produce upon the human body, as follows (1) Tear gases which affect the eyes. (2) Nose irritant gases. (3) Lung irritant gases. (4) Blister or vesicant gases The known war gases are detailed in the accompanying table (Fig. 13) from which it will be seen that present-day respirators will give complete protection against all of them except blister gases

Protection for civilians in the event of a gas attack is obtained by means of gas masks, and special shelters or gas-proof rooms. Soldiers, however, cannot


HOW THE SERVICE RESPIRATOR WORKS

**Fig. 14.** *The Service respirator illustrated in detail above, is designed to withstand the effects of poisonous gases for longer periods than the Civilian Duty and Civilian types It gives complete protection against all the non-persistent gases, and partial protection against the persistent gases, such as mustard and Lewisite, which affect exposed parts of the body*

always take shelter. For them, a gas attack will often have a strategic meaning. Perhaps it is designed to immobilize them while the enemy attack the section of the line for which they are held in reserve. In this case, if they took shelter, the gas attack would have justified itself. For this reason, soldiers and civilians whose duties make it impossible for them to take cover are provided with protective clothing. This clothing consists of knee-length rubber boots and good quality oilskins. The actual garments vary according to particular needs, but include jackets, gloves, aprons and anti-gas curtains or hoods to protect neck and face when wearing a steel helmet. After a gas attack, decontamination squads, wearing this protective clothing can clear away pools of mustard gas or other persistent gases, such as Lewisite, before the "all clear" is sounded

### TYPES OF RESPIRATORS

The most important of all protections against gas attack is the respirator. In Britain there are three types in general use, the Service respirator (Fig. 14), the Civilian Duty respirator and the Civilian respirator The Service respirator is used by the fighting forces and police, and by any who are called on to do heavy work during a gas attack or who may have to remain in heavy concentrations of gas for long periods

The Civilian Duty respirator is designed for the use of members of the A.R.P. services and others whose duty it is to carry out various non-combatant work in the course of a gas attack The Civilian respirator is designed to protect the wearer from any of the known war gases for long enough to enable him to reach shelter.

The Service respirator consists of three parts · the face piece, the container, and the flexible connecting tube The face piece is constructed of stout sheet rubber moulded to the shape of the face. The eye pieces, made of unsplinterable glass, are separate and can be unscrewed for cleaning. The face piece is provided with six elastic bands joined to a rubber pad at the back of the head, the bands being adjustable to suit the wearer.

In the front of this face piece is a metal protuberance, the valve holder. It is a metal disc perforated around its perimeter with a series of holes and its function is to house an outlet valve that allows the free escape of the air breathed out. It is also the connexion through which the purified air from the container is drawn into the face piece by way of the connecting tube.

Wired to the outside of the holder and to the top of the container is the connecting tube This is made of rubber and is corrugated to prevent it kinking with movement and so restricting or cutting off the supply of air Although larger than those fitted to other types of respirators, the container is the same in construction and principle.

All parts of this respirator are carried in a waterproof canvas haversack and when not in use this is carried slung over the shoulder. The haversack is divided into three compartments, two of which hold the face piece and container while the third contains "anti-dim" compound for the glass eye pieces, anti-gas goggles, etc When it becomes necessary to wear the respirator, the haversack is swung to the front of the body and raised so that it lies on the chest

### CIVILIAN DUTY RESPIRATOR

The Civilian Duty type consists of two parts, the face piece and the container, to which it is attached directly by means of a stout rubber band The face piece is attached to the wearer by means of six rubber bands that can be adjusted with buckles It contains two removable eye pieces of unsplinterable glass similar

to the Service respirator. As the container is attached directly to the face piece, it admits purified air direct to the wearer. For expelling air breathed out the container is provided with a non-return valve in the form of a rubber teat. This valve opens as the air is expelled and closes as air is drawn in through the container. Civilian Duty type respirators have a slight protuberance in the left cheek. This is provided so that a microphone can be fitted to enable telephone operators to continue their duties whilst wearing the mask.

The Civilian respirator, although the simplest in construction, is none the less effective. The face piece is constructed of sheet rubber having a large window of non-inflammable transparent material for the eyes stitched securely into place. The face piece is held in position by three webbing straps adjustable to suit individuals, and secured to it by means of a strong rubber band just below the window, is the container through which the purified air is drawn. The air expelled by the wearer passes between the cheek and the edge of the rubber face piece, this being sufficiently flexible to permit it to close against the cheek as fresh air is drawn through the container.

### HOW THE AIR IS FILTERED

The containers of each type of respirator are constructed on the same principle and consist of an outer casing containing a non-return valve. This opens to admit air as the wearer breathes in, and closes as breath is expelled. This causes the expelled air to pass through the outlet valve, or in the case of the Civilian mask past the edge of the face piece.

Inside the container is a particulate filter of muslin that prevents the passage of finely divided smokes such as the arsenical gases. There is also a compartment containing activated charcoal to absorb gases such as phosgene, mustard gas, etc. These contents do not deteriorate with age or with wearing the respirator when gas is not present. That the activated charcoal completely absorbs the gases can be shown by a simple experiment If some of this charcoal is placed in a glass jar containing a gas that is visible—such as bromine—it will gradually be seen to disappear. Even after removing the charcoal and subjecting it to a searching analysis no trace of the gas can be found to be existent.

### TACTICS OF COUNTER ATTACK

We have already mentioned that the aim of a gas attack on positions behind the front lines may well be to immobilize the troops while the enemy attack The striking power of an army in wartime depends upon the army's capacity to deliver lightning counter strokes, once the sting has been taken out of the enemy attack by the fortified positions. The precautions taken against gas attacks are generally so successful that the enemy take other steps to make the counter attack a failure. The success of a counter attack depends largely upon surprise. If the enemy do not know from which direction it will be delivered they cannot prepare to meet it. For this reason they attempt to discover the disposition of the troops held in reserve

Many methods are used by both sides to discover exactly how the opposing troops are disposed. Patrols go out from the front lines to try to capture prisoners. The badges and ranks of prisoners taken will give away the position of their regiments even if the prisoners themselves refuse to answer questions. Reconnaissance aircraft can also spot troop movements and report them to headquarters. In addition, spies are employed by each side.

The successful spy is rarely the glamorous character of sensational fiction. He is more likely to be a very ordinary


HOW SPIES SEND THEIR INFORMATION

*A spy's greatest difficulty lies in sending information home Some of the ingenious methods adopted are shown above* (A *and* B) *Code message visible when head is shaven* (C) *Dots and dashes scored on teeth of comb to make up a message* (D) *Code cut on string of beads* (E) *Cipher key given by cutting perforations of stamp on envelope*

and unobtrusive fellow, carrying out quite a normal peace-time occupation. He may be a commercial traveller, in which case he will be a genuine one obtaining genuine orders He may be a lorry driver earning and living on a few pounds a week. The information he wants to obtain will probably be quite ordinary information available to any one who travels about the country keeping his eyes and his ears open. But when these little bits of information are received from a dozen different sources, enemy headquarters can piece them together to form an accurate picture of what is happening behind the lines.

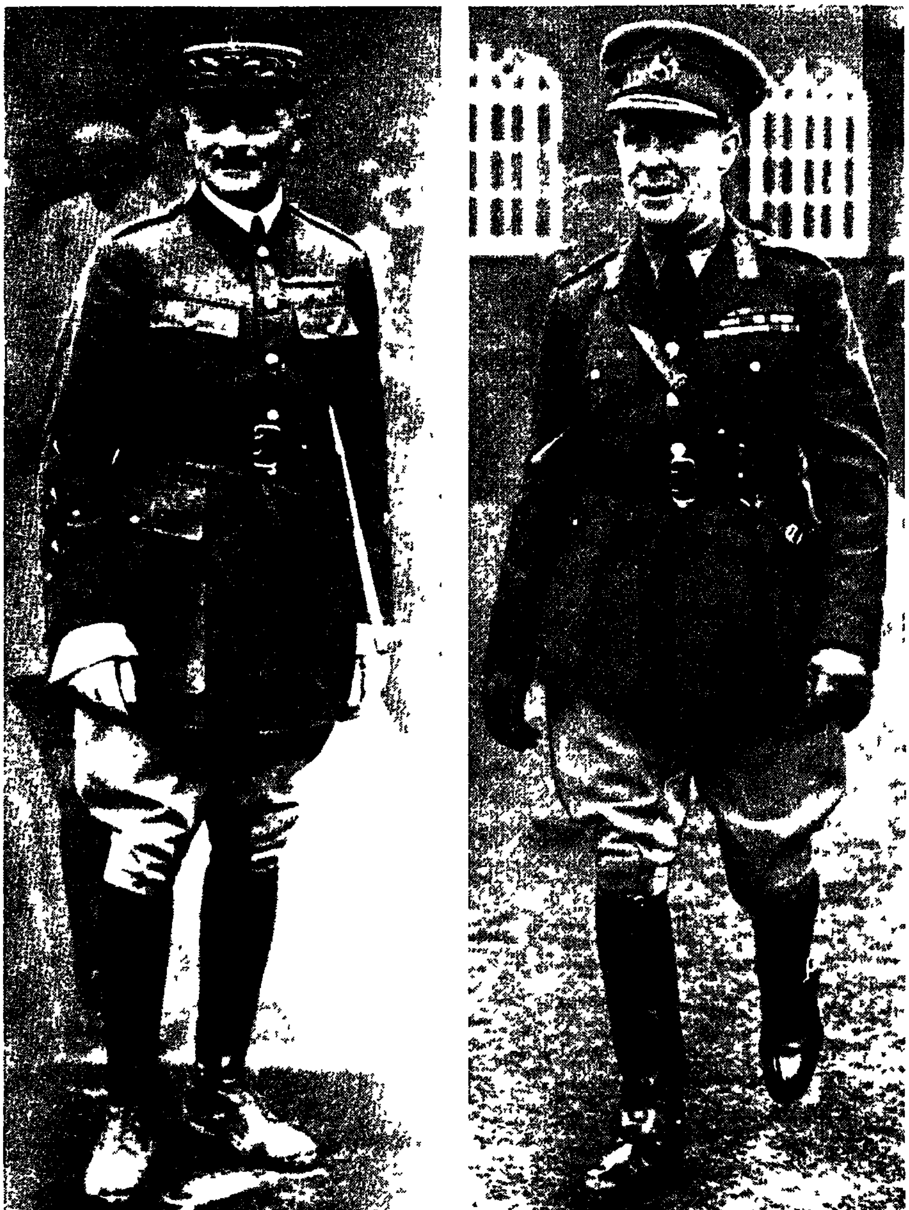
### COUNTER ESPIONAGE

The British Army has a counter espionage service second to none The spy's greatest difficulty is not in collecting his information, but in sending it home. All sorts of ingenious methods are used, and it is the duty of counter espionage agents to detect them. During the war of 1914-18 when the Germans occupied most of Belgium, spies were able to send their messages through the lines. Hollowed out coins and bars of chocolate often concealed tiny pieces of rice-paper Information is sometimes sent in letters via neutral countries This information may be written in invisible ink, or it may be embodied in an ordinary letter, in code As long as the spy remains unsuspected he stands a very good chance of getting it through.

Calm nerves and a cool head are the chief requirements of the spy. Lord Baden-Powell has revealed that once, when acting as a spy, he was arrested by a policeman on suspicion. While awaiting the officer who was to question him, he asked in casual tones whether he might smoke The policeman raised no objection, so Baden-Powell rolled a cigarette and smoked it, and then smoked another. After that he knew that he was safe, for he had made his notes on cigarette papers and had smoked the only evidence against him

Nevertheless, spying is not a very lucrative profession German spies in England during the war of 1914-18 were paid £6 a week. Even then they would have aroused suspicion if they had appeared more opulent than was usual for the job used as a cover for their spying Very few of them remained undiscovered by the British counter espionage agents. Not all of them were arrested, for often a spy can be an asset to the other side His messages can be tapped and false information substituted to make a surprise attack an even greater surprise.

We have now seen something of the many forms of defence that the Army must employ. With all its complexity, modern warfare is still based on the principles that have held good for thousands of years. The steel and concrete of the Maginot Line, the huge guns, the tangled webs of barbed wire, camouflage and counter espionage, all help the Army to hit without being hit, and to move without being seen. Behind the vast machinery of modern defence there still lies Man, and it is upon his capacity and courage that the result of a conflict ultimately depends.



GENERAL WEYGAND AND VISCOUNT GORT

*General Weygand succeeded General Gamelin, as Chief of the French General Staff and Commander-in-Chief of the Allied Forces in France, on May 19, 1940, after the German break through at Sedan Viscount Gort appointed Commander-in-Chief of the B E F, in September, 1939, led the British troops in the Low countries following the invasion of Belgium and Holland*

# CHAPTER XV

# HOW BATTLES ARE FOUGHT TODAY

THE battle front in a modern war may be hundreds of miles long. Here, sometimes face to face, at other times entrenched in fortified positions miles apart, the combatants are locked in their terrible struggle. Far above them the aircraft of the opposing armies strive for supremacy in the air, and from behind the lines their guns hurl destruction.

Yet battles are not fought by the men in the front line alone. The armies have to be supplied with food and munitions and the lines of supply may extend for some thousands of miles. Total war, as it is called today, is a death struggle between nations, and every citizen of the countries involved becomes a combatant. All resources are used. Men and material must be thrown into the battle. On the sea the rival navies safeguard their own shipping while attempting to destroy that of their enemy. On the home fronts industry must be adapted and harnessed to the furtherance of the war effort.

### MEN AND GUNS

Nevertheless, battles are still won in the front line Economic forces and blockades may undermine the enemy defences, but ultimately the enemy strongholds must be captured by tanks, aeroplanes and guns. Victory still depends on the strength of a nation's arms and upon its ability to use them.

The vast destructive forces of a modern army are used according to certain principles of strategy. Strategy must consider what enemy forces are to be met It must decide how, when and where they can be overthrown, or, since strategy may be defensive as well as offensive, how they may be repelled. The first object of strategy is to defeat the enemy's main force. If that is done he must collapse. The strategist must find the vulnerable spot and then inflict the fatal blow.

The term strategy has a wide application. It really means the art of conducting a war, and refers to the disposition of the Army, the Navy and the Air Force, as well as to the use of economic and other weapons. When the Armada was sailing against England, Queen Elizabeth's strategists had to decide whether to meet it at sea, or whether to wait and deal with the invaders when they had landed. It has always been a principle of British strategy to maintain command of the seas.

In September, 1939, a major strategic decision was to send a British Expeditionary Force to operate from bases in France as in 1914. The tactics decided on for this force were at first defensive and so the role played by the British Army during its first winter in France was primarily one of preparing for a trial of strength yet to come.

In modern times strategy is the business of a Supreme War Council, who make these decisions It is the duty of those in command of the forces to see that these decisions are carried out.

When the armed forces are once engaged, the measures taken in the battle itself are called tactics. It is important to preserve a distinction between strategy and tactics, although both are necessarily closely related.

Tactics have been defined as the

conduct and disposition of the struggle itself, while strategy is the measure enabling the forces to enter the struggle favourably Similarly, tactics have been described as the study of forces in combat, and strategy as the study of the combats themselves This definition seems particularly apt in view of the widespread nature of modern war Indeed, a war today consists of several simultaneous wars, all related. Thus, only strategy can decide where the available forces can best be employed, and which is the master key that will open the door for final victory.

### APPLICATION OF TACTICS

In any particular theatre of war, however, tactics are the concern of the armies Commanders must deal with specific military problems—such as how to advance through wooded country on an enemy holding the hills beyond, how to find out which places are strongly defended, and which lightly held; how best to employ in attack the aeroplane and the vast weight of modern mechanized forces, how to resist any counter attack, and how to make good a retreat

Tactical methods have been evolved for all these and the many other operations of war. The commanding officer's business is to know and to apply those tactics to the operations for which he is responsible.

Having explained the meaning of the terms *strategy* and *tactics*, we shall, in this chapter, discuss their application in modern warfare, and attempt to show how the striking power of the British Army in the field is built up and employed

To put into battle such a vast British Army as modern warfare demands requires elaborate preliminary preparation. The War Office must arrange to deal simultaneously with innumerable aspects of the conflict. For example, enemy arrangements and intentions must be discovered as far as possible. To meet the vast munitions supplies necessary, the Government must harness the country's industrial capacity

As we have seen in an earlier chapter, the Army Council is in supreme control The Chief of the Imperial General Staff (Fig 1) has the responsibility for planning operations in addition to collecting intelligence and directing military training The raising and organizing of the forces in peace time is the work of the Adjutant-General. Transport, supply, movement, catering, fortifications and building in general is the concern of the Quartermaster-General's department Each of these departments has a host of related problems to solve in actual warfare. They range from evolving methods of countering new weapons—even such "weapons" as propaganda shouted by giant loudspeakers across no-man's-land —to the part to be assigned to women in the auxiliary forces. Every emergency of warfare has to be foreseen and provision made to meet it

Reaching out from this nerve centre to the farthest outpost of the war are the systems of communications and supply, on which the movement of the war machine depends. Infantry, artillery and newly-mechanized cavalry arms must be supported by engineers, signallers and other specialists needed to perform indispensable services

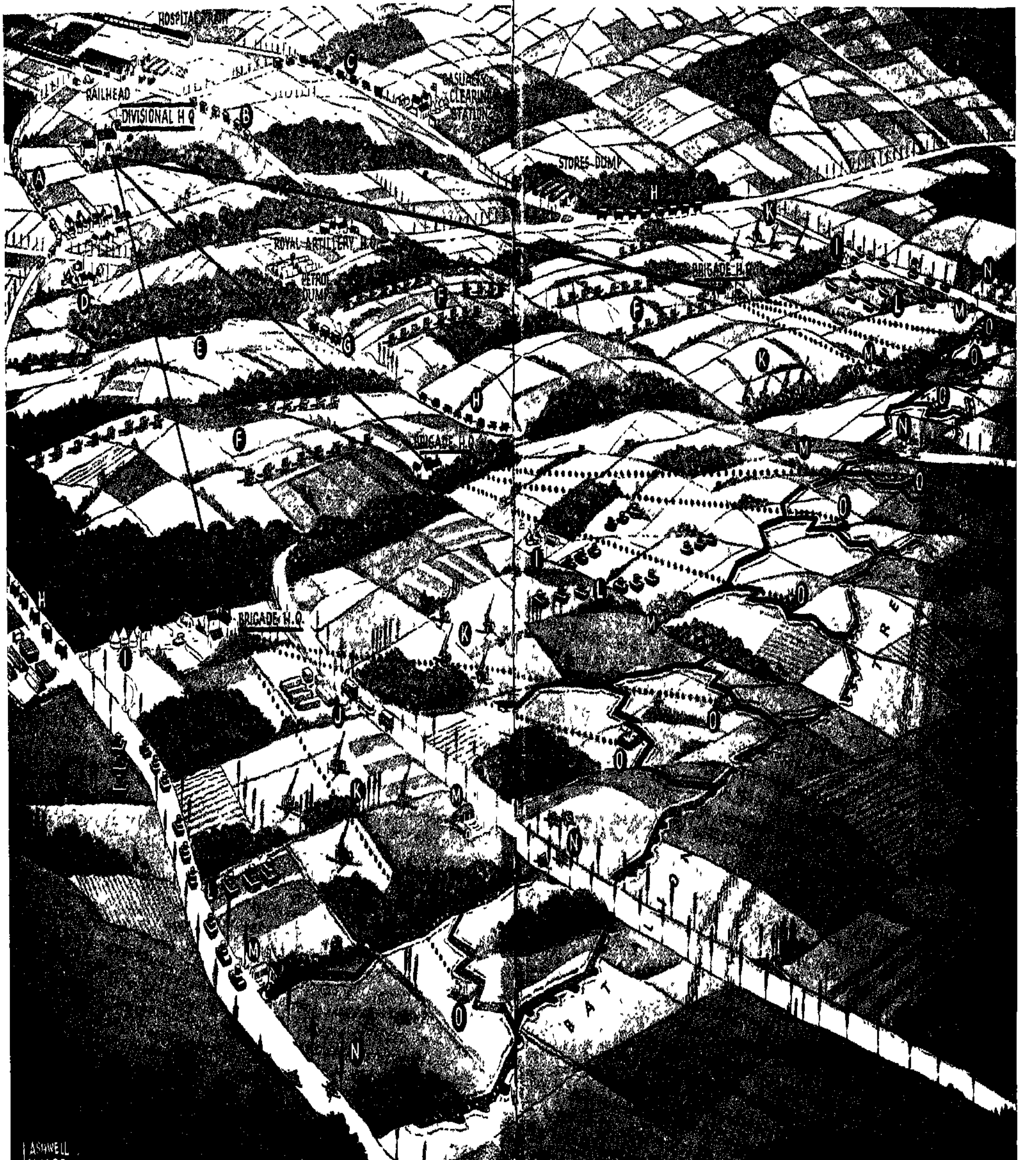
It is on the battlefield itself that effective co-operation of all these services to meet the different tactical requirements is seen (Fig 2). These requirements vary from hour to hour, according to whether defence, attack or protective tactics are in force. Schemes are laid down for covering all likely contingencies—such as the taking of occupied villages, fighting in wooded country, and the crossing of rivers—for in all situations the nature of the country must be considered.

CHIEF OF THE IMPERIAL GENERAL STAFF

**Fig. 1.** *General Ironside was appointed Chief of the Imperial General Staff in September, 1939 The duties of the C I G S embrace the collection of intelligence, the direction of training, the control of staff duties and the planning of all military operations*

The methods of attack must depend not only on the nature of the country, but also on the armament of the enemy. The spearhead of all modern attacks is the bombing aeroplane which prepares the way for the heavily armoured tanks that lead mechanized forces into battle. The lighter mobile forces, tanks and armoured cars spread out through any gap forced in the defences and devastate the enemy's back areas. Infantry follow in trucks to consolidate and mop up the positions won Artillery, except field and anti-tank weapons, is used more and more as a support for the bomber. These tactics were employed successfully by the Germans against Poland and Holland and the attack on France in May, 1940.

One of the main principles of attack is surprise, but this is difficult to obtain in modern warfare. For any large-scale attack a large number of troops, tanks, etc., are necessary, and it is difficult to hide any large concentration of such




HOW THE VARIOUS UNITS OF A BRITISH ARMY DIVISION ARE DISPOSED IN THE FIELD OF BATTLE

**Fig. 2.** *This compact bird's-eye view shows the layout of an army division of some 25,000 men Starting at the top left hand, one can follow the organization right down to the front line from the key letters* (A, B, C) *Ammunition, petrol and stores transport from railhead to dump* (D) *Divisional signals, three companies* (E) *Heavy regiment, R A, four batteries of four 8-inch howitzers* (F) *Three field artillery regiments, R A, six batteries of twelve guns each* (G) *Three field companies, R E* (H) *Three ambulance columns, R A M C, eight vans each* (I) *Three field main dressing stations, R A M C* (J) *Field park company, R E* (K) *Four batteries anti-aircraft guns, R A* (L) *One tank battalion, three companies of fifteen tanks each* (M) *Six advance dressing stations, R A M C* (N) *One anti-tank regiment, R A, four batteries of twelve guns each* (O) *Headquarters for the nine infantry battalions*

forces from reconnaissance by enemy aircraft unless complete supremacy of the air has been obtained. A single inquisitive aircraft might take back to the enemy lines information or photographs that would disclose the attackers' intentions. Then again, as so often happened in the 1914-18 war, the preliminary air or artillery bombardment of enemy positions may in itself be sufficient to indicate an impending attack. Only the "zero hour" will be unknown to the enemy.

#### THE UNEXPECTED IN ATTACK

In theory, however, the attackers should strike unexpectedly, with all the force available Preparations must be secretly and skilfully carried out, so that there is no chance for the enemy to reinforce his defences at the threatened point. One important part of tactics is to make the best use of cover afforded by the ground in arranging the secret assembly of the attacking troops. Speed in the execution of the task, as soon as the signal is given, is another big factor in achieving a successful surprise

Immediately the attack has disclosed a weakness in the enemy position the tactical principle of concentration must be applied, to bring superior forces to bear at the decisive point Thus mobility is another tactical principle, which by a success can be exploited by reserves, while at the same time continuous pressure can be applied all along the front

The attacking force is divided into forward units and reserves. While the maximum strength is being thrown into the decisive point of attack the reserves must be ready to follow up success, or to secure the main objective if the forward troops fail to do so Reserves also fill gaps in the attack by replacing casualties, form rallying points for the forward troops, meet counter attacks, and hold captured ground

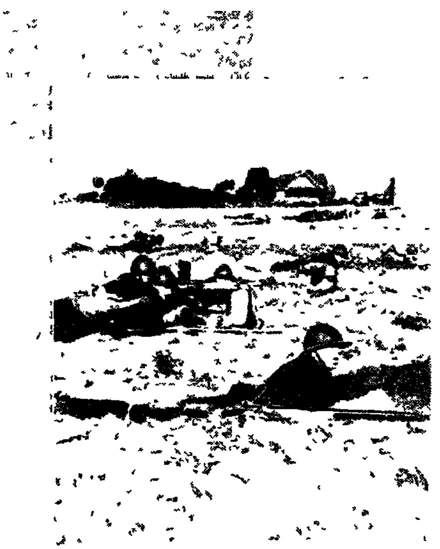
The tactical unit of infantry employed in such attacks is the rifle platoon There are three sections in a rifle platoon, eight men to the section. Any section can be used either as a fire unit or as an assaulting unit. It is the largest body of men that can be under the immediate personal control of its leader in a battle

Every man has his own rifle with ten rounds in the magazine, another forty rounds in reserve, and his bayonet. In addition, each man carries three magazines for the Bren gun, except one man who acts as battle reserve. Distributed among them they also carry four high-explosive grenades and the discharger cup, eight smoke grenades, as well as the Bren gun itself

The Bren gun will have been brought as near as possible to the point of the attack in the platoon truck This truck carries the two other Bren guns for the other sections in the platoon and normally one Bren gun is always mounted in the truck for anti-aircraft purposes Besides the ammunition for the Bren guns and rifles, the platoon truck will carry an anti-tank rifle with the necessary armour-piercing ammunition, and supplies of grenades, dischargers and discharger cups There will be a signal pistol with three red, three white, and three green lights, as well as wire cutters and hedging gloves

Other equipment on the platoon truck will include nets for camouflaging the guns, etc , ten picks, thirteen shovels, a felling axe, two hand axes, a folding saw and three billhooks. In addition, there will be greatcoats, packs and ground sheets for all the men in the platoon

Before the attack the platoon commander will have issued his instructions, based on the orders of his company commander. He will have explained the objectives, and stated the assembly position and forming-up place, as well as the direction and method of advance. Distances and bearings will also have been



[D, British Official Photograph, Crown Copyright

ACTION PICTURES FROM THE WESTERN FRONT

*Siege warfare, as when two vast defensive systems such as the Maginot and Siegfried Lines oppose each other, is not sensational or dramatic Isolated patrols* (A *and* B), *the crossing of wire* (C) *and guerrilla warfare* (D) *provide most of the action*

stated, the starting line defined, and the full details for the signalling and timing of the attack given. He will also have explained what smoke screens will be used in the attack and will have described the landmarks.

### DUTY OF SECTION COMMANDER

The duty of the section commander will be to lead his men along the line of advance, his principal task being to make sure of his direction, and to co-operate with the sections on both flanks. He must also choose the appropriate fire positions, see that fire discipline is maintained, and prevent waste of ammunition. Incidentally, he must also collect ammunition from casualties.

Keeping well in touch with his platoon commander, the section commander must report the position of the enemy and any unexpected obstacles encountered. On arrival at the objective he must maintain contact with the enemy and take full advantage of any chances to press the attack.

Since a section probably consists of only a corporal, lance corporal, and six privates, its place in the vast scheme of war may seem almost inconsiderable Even our brief survey of some of its tactical duties will have shown, however, the amount of initiative and skill that are called for in battle. The three sections of a platoon with associated equipment make it an infantry battalion in miniature. Motorization has made the platoon self-contained and self-sufficing, and it is now the basic unit of the British infantry.

The work of the artillery starts before the battle and continues after the actual fighting has ceased. Roads and railways of the enemy must be shelled, and his communications destroyed. Forts, emplacements, gun positions and trenches must be bombarded.

The word barrage really means a solid dam that stems a flood. So intense is modern artillery fire and so successfully can it prevent the approach of enemy troops, that the term "artillery barrage" is an apt description of concentrated fire.

At the point of attack the range of the artillery may be suddenly increased a moment before zero hour, to permit our own troops to advance through the shelled zone, the barrage being lifted again periodically according to a prearranged programme timed almost to a second. Because this kind of barrage is generally lifted in successive stages, it is called a "creeping barrage."

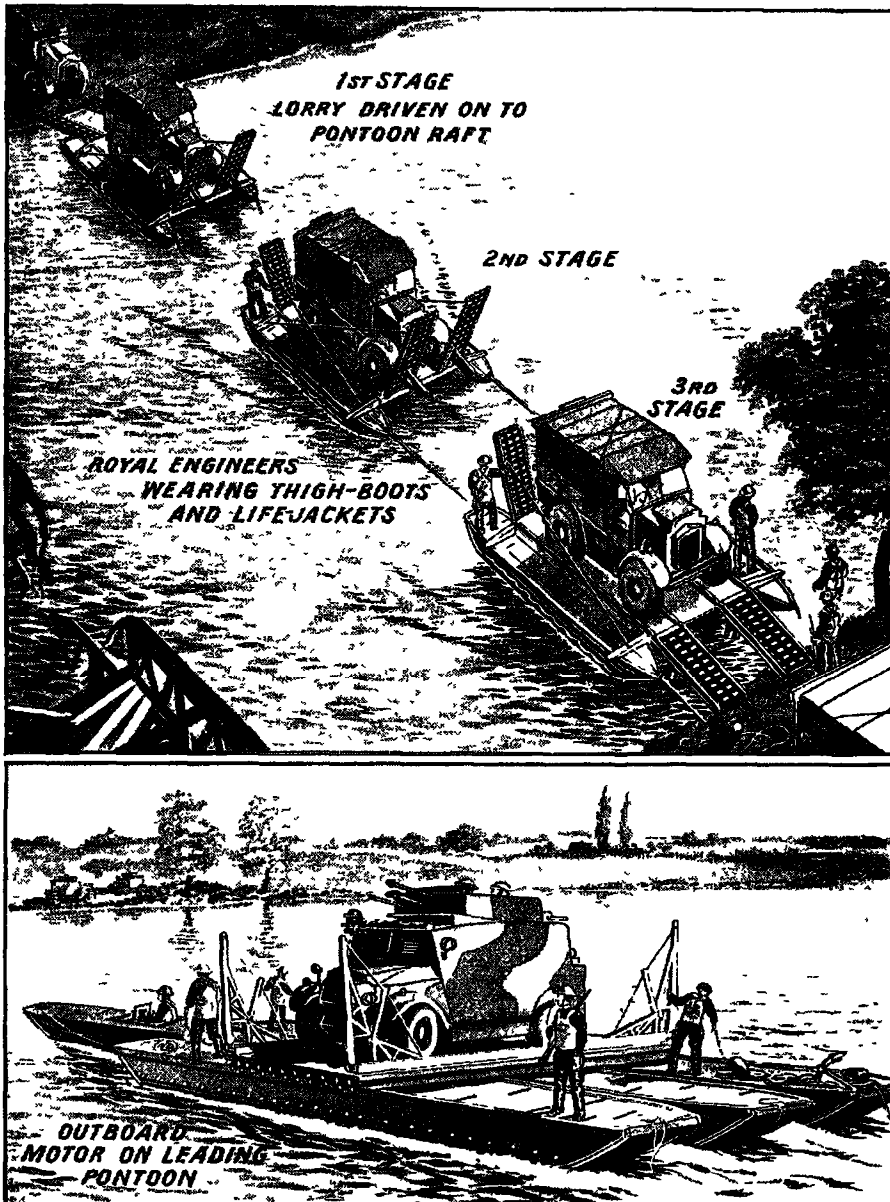
In defence, as in attack, forward observation officers attached to the artillery watch for enemy movements and report back to the batteries. Aircraft also spot for the guns, reporting their observations by wireless (*see* pages 129 and 130).

### POSITION OF ARTILLERY

The field guns occupy the most forward artillery positions. They may be disposed in depth by batteries or by sections. Some will be located near the main rearguard and others near the reserves. The long-range guns are placed farther back, the heaviest often being some miles to the rear.

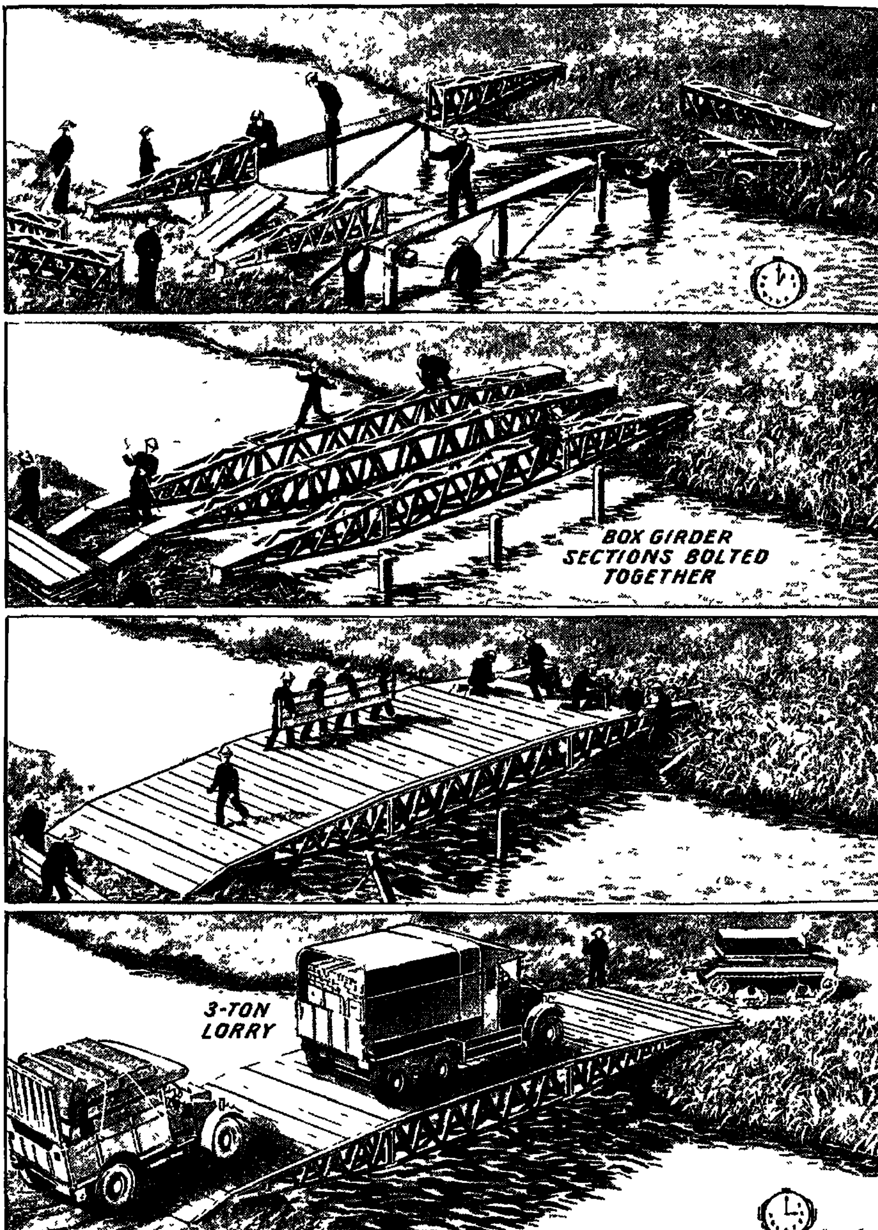
Although infantry may still attack independently they require more and more the co-operation of bomber, gun and tank. Indeed, infantry are tending to become the servants of mechanized forces rather than their masters and cavalry, today riding in tanks and armoured cars instead of on horses, is again coming into its own. Light mechanized cavalry is particularly valuable in covering any retreat.

Co-operating with the artillery, infantry and all other branches of the Army, the Royal Engineers carry out work involving specialized engineering (Figs 3 and 4). R.E field squadrons serve cavalry divisions, while field companies and field park companies accompany




HOW ARMY LORRIES ARE TRANSPORTED ACROSS RIVERS

**Fig. 3.** *Units of the Royal Engineers are attached to every branch of the British Army to carry out all work requiring specialized engineering. This picture illustrates the method by which Royal Engineers, dressed in thigh-boots and life-jackets, and working often under fire, transport comparatively heavy vehicles across streams and rivers on pontoons.*




ROYAL ENGINEERS SPAN A STREAM IN TWO HOURS

**Fig. 4.** *These pictures show how the skill and ingenuity of a unit of the Royal Engineers, such as is attached to each Army branch, make it possible to build in two hours a strong bridge spanning an awkward stream, and drive mechanized vehicles over that bridge The R Es are "building contractors" to the Army, and no job is too difficult for them*

infantry divisions. Higher formations have army troop companies, electrical and mechanical companies, field survey companies, and companies of technicians allotted to them.

Making trenches, bridging and road maintenance are of great importance to a mechanized army in action Units of the Royal Engineers are equipped to do all the work normally required by the division to which they are allotted. Some of the heavier and more permanent feats of engineering call for special equipment, and this is provided by the special R.E. units allotted to higher formations.

Among these special duties of the R.E. is the construction of mines (Fig. 5)—carried out by the tunnelling companies—perhaps beneath some fortified enemy position, that may hold up the attack and which, for some reason, cannot be dealt with effectively by the artillery.

Many mines were exploded in the 1914-18 war. As a typical example, we may mention two large mines laid in the Somme offensive (July 1, 1916) These mines, which were to be fired two minutes before "zero hour" when the general attack was timed to take place, extended below a salient around La Boiselle. One contained 40,600 lb. of ammonal and the other (under the formidable Schwaben Redoubt) 60,000 lb of ammonal The gallery of the former mine was 1,030 feet in length—the longest tunnel to be driven during the war—and was driven through chalk.

All operations were carried out in silence. Bayonets fitted with special spliced handles were used for digging, and the men worked barefoot on a floor carpeted with sandbags The man at the working face inserted the point of his bayonet in a crack in the chalk and by giving the bayonet a thrust dislodged a piece of chalk This he caught with his other hand and placed on the floor. The chalk was packed into sandbags and passed along by a line of men seated on the floor of the gallery. Later it was used to "tamp" the charge. The tunnel was about 4 feet 6 inches square and an advance of 18 inches in twenty-four hours was thought to be good going. The mines, which were exploded at 7 28 a.m , blew up the German garrison and caused a great crater 270 feet in diameter and 90 feet deep.

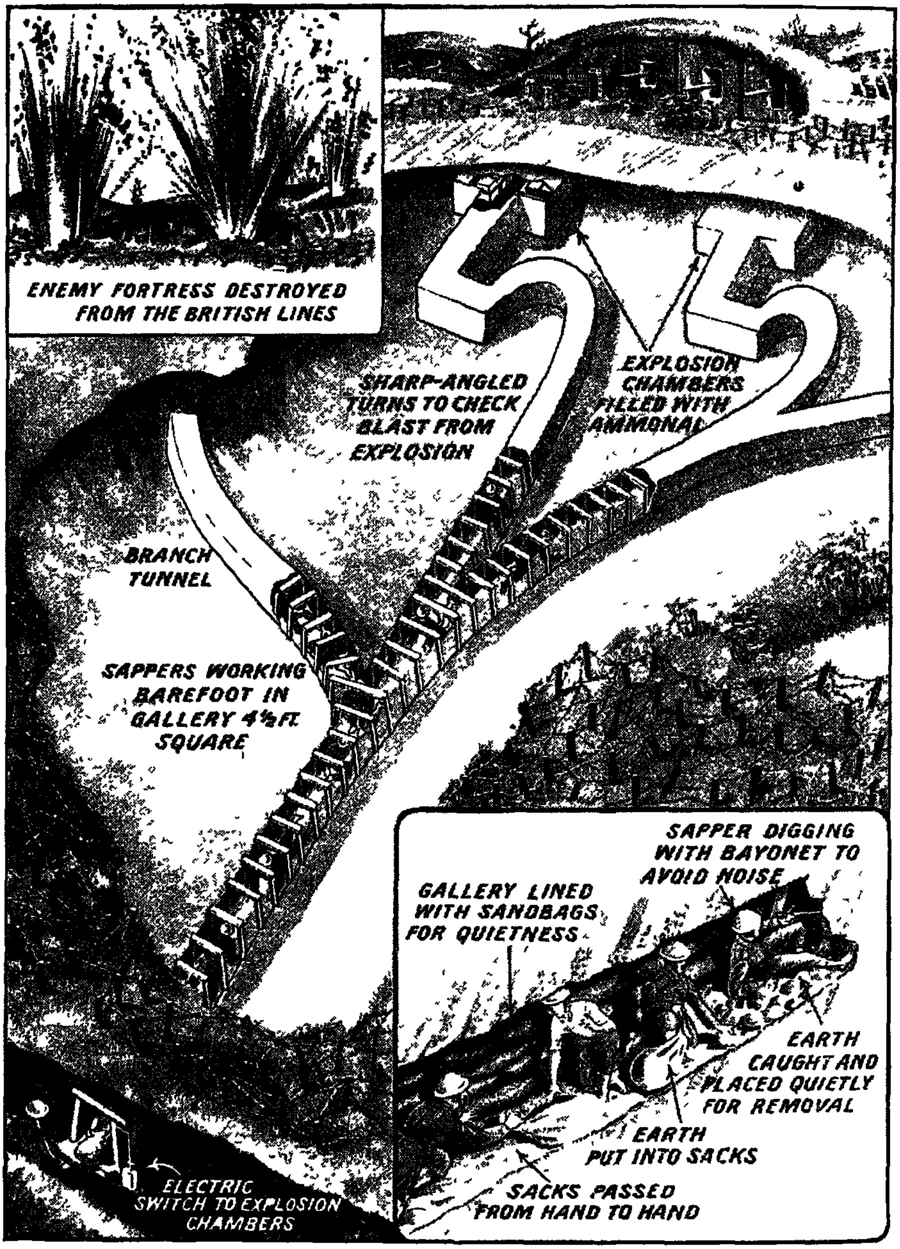
The preparation of booby traps over ground that the enemy must cross is also undertaken by the R E. Some typical traps are shown in Fig. 6.

Another duty of R.E. field units is to provide and improve water supplies—often a factor of the greatest importance when troops have been hard pressed. Besides such vital supply services, there are many other important activities such as the demolition of dangerous buildings or of bridges in a retreat.

### COMMUNICATION SYSTEMS

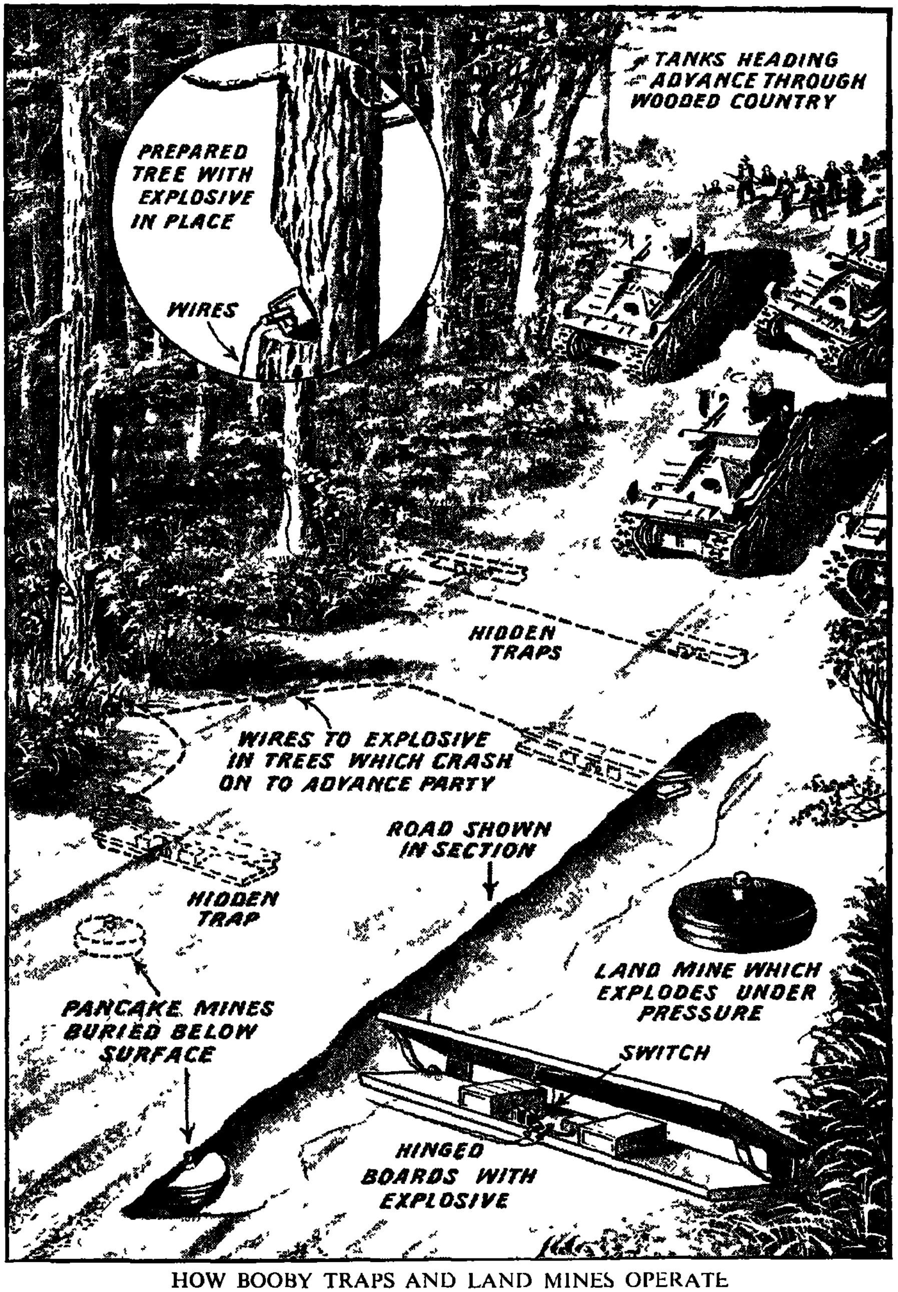
All these different branches of the Army must work in close collaboration, and to do this they need a complicated network of communications. This wonderful system of communications links all the different forts and bases and stretches from the War Office to the most distant unit in the field. As we mentioned in an earlier chapter, the *maintenance of this system is chiefly in* the hands of the Royal Corps of Signals. They must not only carry on in the face of intense enemy opposition, but must also cope with the kaleidoscopic changes of situation that characterize an attack. From bases to the field headquarters, and then on to the bullet-swept positions within sight of the enemy, they lay their lines Time and time again they are shot away and have to be replaced.

Just as important to the Army as its lines of communication are its lines of supply. The work of the Royal Army Service Corps is a task of almost



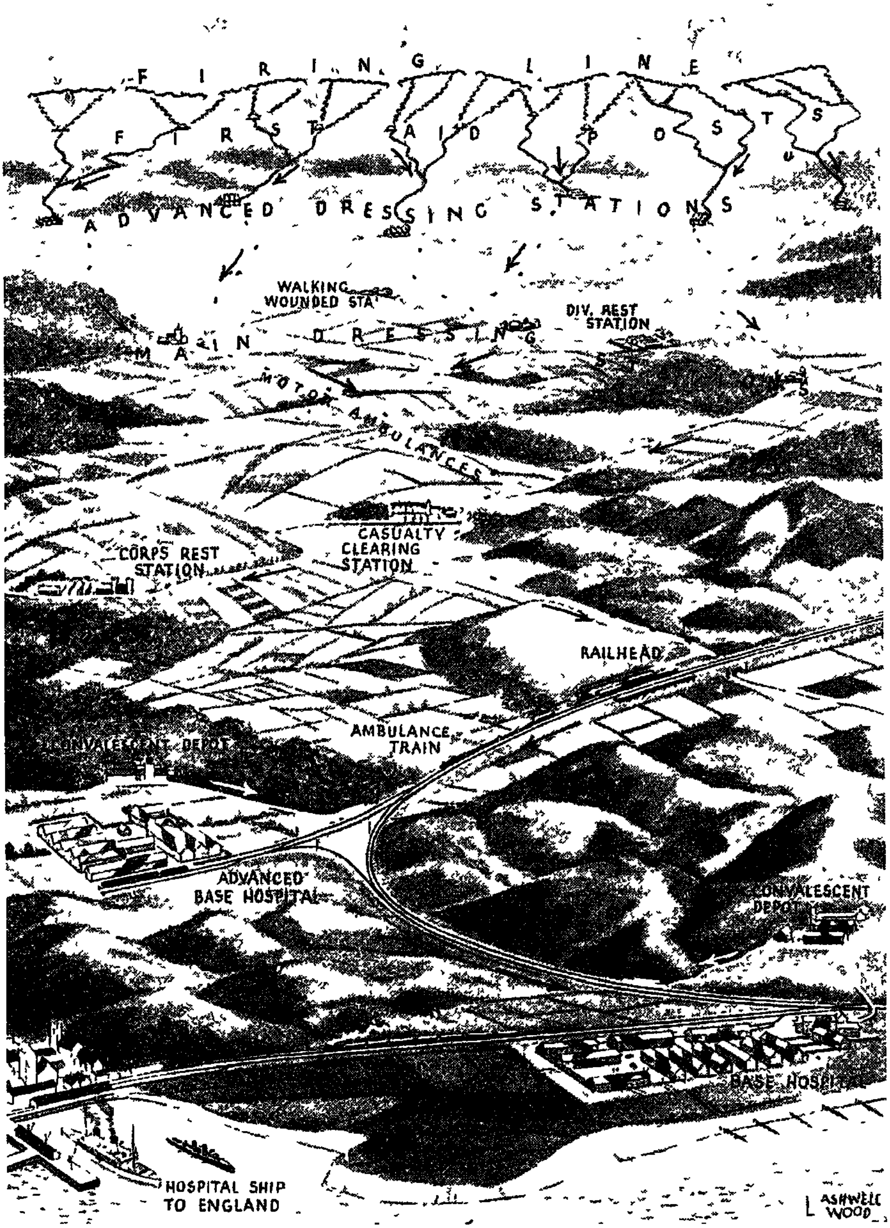

CONSTRUCTING A MINE UNDER ENEMY LINES

**Fig. 5.** *The tunnelling companies of the Royal Engineers have, in wartime, a hazardous and back-breaking task Only a minute amount of work can be accomplished at a time, and a whole tunnel may take months to complete The dangers of counter mining, suffocation, collapse of the workings and exploding of the charge are always present*




HOW BOOBY TRAPS AND LAND MINES OPERATE

**Fig. 6.** *The Royal Engineers, in addition to their numerous other duties, are responsible for the preparation and planting of land mines and other traps over terrain the enemy are expected to cross These devices may seriously delay enemy advances*




DISPOSITION OF R A M C UNITS IN WARTIME

**Fig. 7.** *This artist's impression tells what happens to a wounded soldier from the time he leaves the firing line to his embarkation for "Blighty" on the hospital ship The whole of this organization is the responsibility of the Royal Army Medical Corps*

unbelievable difficulty at all times, and especially during an attack. They bring up the food, petrol, oil, stores, and ammunition. All fighting units must have two days' supplies within easy reach and these must be kept replenished whatever difficulties may arise. An immense transportation employing road, rail and ship is involved The final distribution to individual troops is carried out by the vehicles of the unit concerned. Second line transport consists of the R A S C vehicles allotted to the unit for the carriage of supplies. It links up with the third line transport columns and parks serving the railheads to which the stores are delivered from the bases.

Ammunition supply alone is an immense task, for it involves the reception, sorting, storage and delivery of an infinite variety of materials In one day the British Expeditionary Force of 1914-18 expended 12,600 tons of ammunition. The mere bulk handled and its delivery under difficult field conditions present most formidable difficulties. From railhead it is picked up by the lorries of the corps ammunition park and taken to the ammunition refilling points. Here it is handed over to the divisional ammunition company which distributes it to ammunition points, situated where reserves can be held "on wheels." From this point the final distribution to particular units is made.

In battle an infantry brigade will probably form its own reserve of small arms ammunition. The brigade reserve will deliver to the battalions, and distribution thence will be by means of the company vehicles or by hand to the men in the firing line.

Finally, we must say a word about the work of the Royal Army Medical Corps, whose work is comparable in complexity with that of the R.A.S.C except that the corps handles a living load

The work of the R.A M C. begins in the forefront of the battle (Fig. 7). The evacuation of the sick and wounded begins in the collecting zone, where field ambulances form the main and advanced dressing stations. In a battle these stations render first aid to the walking wounded, while bearers bring in the more seriously wounded. From here motor ambulances move them to the main dressing stations or to the casualty clearing station.

### DEALING WITH CASUALTIES

There is normally one casualty clearing station to each division. It either sends the wounded farther back by the ambulance trains (each of which can accommodate from 300 to 450 men) or alternatively, the wounded may be transferred to rest stations from which some are later able to return to their units.

Near the line of communications, along which the ambulance trains move between their bases, are the general hospitals, normally two to the division. Finally, the hospital ships link the base hospital with the home railways, where again ambulance trains take the more seriously wounded to their destinations.

We have now briefly surveyed the immense organization of battle. Obviously such a survey can but touch on a few highlights, for the modern battlefield is indescribable—the intensity and complexity of the operations involved are almost unimaginable. But despite the appalling bodily destruction, the battle serves to remind us that Man's spirit is unconquerable. Quite apart from the heroism and devotion so often displayed on the field, war provides the most amazing example of what men will do and endure to perform their duty.

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